CONSERVATION INNOVATION GRANTS
Final Report

I. COVER PAGE

Grantee Name: American Farmland Trust	
Project Title: A Multi-Faceted Approach to Achieving Nutrient Reductions in the Upper Salt Fork in Champaign County, Illinois	
Agreement Number: #69-3A75-10-140	
Project Director: Brian Brandt	
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Period Covered by Report: 10/1/2010 to 9/30/2014	
Project End Date: September 30, 2014	
Date of Submission: March 10, 2015	

Project Deliverables as stated in the NRCS-AFT Agreement

1. Advancement of the BMP Challenge Yield Guarantee Tool in the Mississippi River Basin Initiative (MRBI), Upper Salt Fork Watershed.
2. Install Demonstration site within the MRBI, Upper Salt Fork Watershed.
3. Install edge of field monitoring to track water quality in the MRBI, Upper Salt Fork Watershed Demonstration site. Demonstrate current and ongoing edge of field monitoring that can be modeled by other landowners with similar conditions using Paired Monitoring techniques developed by the University of Illinois.
4. Conduct at least one survey annually of producers and suppliers on the effectiveness of the BMP Challenge Program in the MRBI, Upper Salt Fork Watershed.
5. Attend at least one NRCS CIG Showcase of comparable NRCS event during the period of the project agreement.
6. Semi-annual performance progress report and a final report documenting accomplishments of products sited for Achieving Nutrient Reductions in the Upper Salt Fork Watershed in Champaign County, Illinois through an Innovative and Multi-faceted Approach.
7. Fact sheet describing the new technology or approach.

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III. EXECUTIVE SUMMARY

This project was a proactive and collaborative approach – utilizing multiple funding sources and programs – working one-on-one with farmers to advance their adoption of new conservation practices and fine-tune nitrogen management systems while ensuring that their adoption will not result in loss of yield and recognizing and promoting the economic benefits. It was designed to be a multi-faceted approach that would determine the barriers to adoption in the watershed, provide a roadmap for addressing those barriers, create demonstration sites to educate farmers, offer farmers multiple programs/tools to implement BMP's and, finally, include a monitoring component to prove the effectiveness of the approach in improving water quality.

The overall project goals were to: 1) Produce a 10 percent to 20 percent reduction in nutrient runoff on participating farms validated by farm and industry production records as well as current in stream monitoring and newly installed edge-of-field monitoring; 2) Utilize multiple information sources to convince farmers on 25 percent of the corn acreage in the sub-watershed to adopt core nutrient reduction practices and new advanced nutrient management practices, including a shift to split and spring fertilizer application systems, precision application technologies, new fertilizer technologies and adaptive management techniques; 3) Identify barriers to adoption and develop a communication and outreach program to reach out to all producers, including underserved communities; and 4) Develop a sustainable plan for scaling up this approach to the state and Mississippi River Basin levels.

AFT identified the following strategies that were crucial to obtaining the desired outcomes: 1. Engage a wide variety of partners and stakeholders; 2. Overcome barriers to adoption by engaging agriculture to develop solutions; 3. Build ongoing support within the agriculture and fertilizer industries; 4. Implement on-the-ground activities utilizing USDA MRBI CCPI and CIG funding in the Upper Salt Fork Watershed and; 5. Secure dedicated funding for and install monitoring sites.

The objectives for the CIG funding secured for this project were:
1. Targeted application of the *BMP Challenge* Yield Guarantee Tool: *Over the three years we planned to work with approximately 60 farmers to enroll 5,250 acres in the BMP Challenge program;* 2. Install an MRBI Demonstration site, and; 3. Install edge-of-field monitoring to track water quality on the MRBI demonstration site.

The activities completed over the grant period resulted in the following accomplishments:

- ***MRBI/EQIP acreage enrolled***
    - Total acreage signed up during 2010 and 2011 for practices: a total of 13 new conservation contracts covering 6,108 (out of a potential 27,500 acres in the sub-watershed) for crop years 2011, 2012 and 2013. Practices applied fall 2010/spring 2011: 2,204.5 acres (2,130.1 nutrient mgt, 74.4 cover crops); approximately 486 acres, fall to spring application.
    - Total acreage signed up in 2012 for practices: a total of 22 new conservation contracts covering more than 4,230 additional watershed acres. The EQIP sign-ups resulted in 10 basic nutrient management, 6 enhanced nutrient management, 3 cover crop and 3 strip tillage contracts.

    - Total acreage signed up in 2013 for practices: a total of 8 new contracts on 578 acres.
- ***AFT and Champaign SWCD cost share program acreage enrolled***
    - The cover crop cost share program implemented in 2013 resulted in 12 USF farmers planting cover crops on 1,495 watershed acres.
    - The cover crop cost share program implemented in 2014 resulted in 34 USF and Champaign County farmers planting cover crops on 2,958 reported acres. NRCS reported 415 acres of EQIP cover crops contracts.
    - The sidedress toolbar cost share program implemented in 2014 resulted in the lease of the appropriate toolbar equipment for six producers in the USF project area through a competitive application process. Each of these six producers that were funded committed to an annual minimum of 500 acres of spring or side-dress N applications for a three-year period. The total acreage commitment each year for all of the producers is nearly four thousand acres and the producers will report the acreage side dressed for each of the next three years.
- ***BMP Challenge:*** The total acreage enrolled in the BMP Challenge program during the project period was 412 acres. 12 fields were in enrolled in the BMP Challenge by 9 farmers implementing nutrient management practices (PSNT and Adapt-N).
- ***MRBI Demonstration Site and Edge of Field Monitoring:*** Two paired monitoring sites implemented through CIG and private project funding secured by AFT are currently producing results in the project area. AFT had hoped to establish four more monitoring sites (two paired sites). Since farmers are not eager to use EQIP funding for monitoring sites on their farms (or other practices), the project relied partly on alternative funding for monitoring sites and ongoing monitoring costs. The university continues monitoring the flow and nutrient loading from a total of ten field tiles in the watershed at edge of field sites. Based on data gathered from our paired sites, the U of I partners found significant reductions in paired drainage sites when cover crops were used on one side and absent from the other side during the previous crop season. Cover crop biomass accumulation of nearly one ton per acre contained more than 50 pounds of N per acre and reduced tile nitrate loss by 50%.
- ***Establishment of Leadership for Midwestern Watersheds:*** Under the framework of the Leadership for Midwestern Watersheds (LMW), AFT, Sand County Foundation, the Iowa Soybean Association, the Iowa Chapter of the Nature Conservancy and others that are leading MRBI projects have been meeting since 2011 periodically to exchange information and share lessons learned about project design and implementation with the goal of improving performance of watershed projects in the Midwest.

The project team also faced several challenges to achieving the goals outlined above. Those challenges included: the unwillingness of some farmers in the USF to engage with the project team in attempting to implement identified practices through EQIP, the BMP Challenge, our local cost share program and an offer of no-cost, one-on-one technical assistance to farmers; farmer "ownership" of the project in the Upper Salt Fork area was more of a challenge than originally anticipated; a delay in payments from NRCS early in the project period discouraged farmers from enrolling/participating in EQIP; the resignation of the project director midway during the project, and; high commodity prices during the project period made conservation payments less attractive to farmers.

Our one-year, no-cost extension granted through September 2014 allowed us to incorporate feedback from the USF Advisory Committee. Thus, during the last two years of the project we focused more on promoting cover crops and nutrient management practices. It also allowed us the opportunity to test a cost share program for cover crops and side-dress toolbars developed by the project partners that utilized a short application and an expedited incentive payment process.

Although we fell significantly short of our goal of having 60 farmers enroll over 5,000 acres in the BMP Challenge program, we achieved all of the other identified deliverables in the CIG project agreement including installing multiple MRBI demonstration/monitoring sites, completing surveys with BMP Challenge participants, attending multiple CIG showcases or other significant outreach events and developing multiple project fact sheets. Furthermore, we were able to achieve significant implementation of targeted BMP's through enrollments in EQIP and the local, targeted cost share program during the project period.

Finally, AFT and its partners experienced many success throughout the project and also had many challenges to overcome. Based on our experience in this project and communications with other MRBI project leaders several recommendations for a strong watershed project were identified and are given below:

- Work through an advanced watershed planning process.
- Establish partnerships prior to seeking funding.
- Develop partnerships that play to each other's strengths.
- Develop non-jurisdictional agreements (MOU's).
- Ensure that there is local "ownership of the project.
- Hire a strong, full-time coordinator to lead the project.
- Develop a farmer led advisory committee.
- Develop and implement a comprehensive communication plan.
- Develop and implement a strong monitoring plan.
- Incorporate an adaptive management process.

IV. INTRODUCTION

The watershed project was designed to utilize multiple funding sources and programs so that over three years, we would: 1) Produce a 10 percent to 20 percent reduction in nutrient runoff on participating farms validated by farm and industry production records as well as current in stream monitoring and newly installed edge-of-field monitoring; 2) Utilize multiple information sources to convince farmers on 25 percent of the corn acreage in the sub-watershed to adopt core nutrient reduction practices and new advanced nutrient management practices, including a shift to split and spring fertilizer application systems, precision application technologies, new fertilizer technologies and adaptive management techniques; 3) Identify barriers to adoption and develop a communication and outreach program to reach out to all producers, including underserved communities; and 4) Develop a sustainable plan for scaling up this approach to the state and Mississippi River Basin levels.

As part of the project, AFT secured USDA MRBI CCPI funding to target producers who traditionally are willing to participate in USDA funded conservation programs and help them cover their costs of adopting core and supporting practices that have been prioritized as appropriate for the project watershed. In addition, AFT secured this CIG to engage in activities that we felt would complement the CCPI funding to achieve overall project goals. Finally, AFT secured private foundation funding to cover costs of project activities not covered by the MRBI CCPI or CIG funding.

Private and federal resources secured by the partners that was leveraged by the $524,970 in CIG funding:

Walton Family Foundation	$240,000
McKnight Foundation	$100,000
USDA MRBI CCPI	$616,327

Goals and Objectives

1. **Targeted and New Application of the *BMP Challenge* Yield Guarantee Tool**: *Over the three years we proposed towork with approximately 60 farmers to enroll 5,250 acres in the BMP Challenge program.* The *BMP Challenge* is a crop yield guarantee that helps accelerate adoption of conservation practices by overcoming the barrier of real or perceived risk of a yield loss/foregone income. Although many farmers fear that BMPs may impact crop yields and income, 60 percent of farmers who try them actually save production costs with little or no negative effect on yields. At the time the project was initiated, discussions were taking place with the office of Deputy Chief for Financial Assistance aimed at including the BMP Challenge system in a new Monitoring and Evaluation Practice Standard to support large-scale use of conservation guarantee tools to help farmers overcome foregone income/risk-of-adoption barriers. AFT also was gathering data about the yield and income impacts of many newer, advanced nutrient management practices and the impacts of implementing multiple practices in a systems approach so they could be added to the *BMP Challenge* program. AFT proposed to (1) Provide late adopter farmers with yield/foregone income guarantees to help implement core nutrient reduction practices; 2) Expand the *BMP Challenge* to include advanced nutrient management practices such as in-season testing and nutrient application to help more progressive farmers implement new technologies and practices; and 3) Modify and expand the BMP Challenge program to have multiple BMPs implemented at the same time in the same field eligible to be enrolled in the BMP Challenge program. Only a single practice change (such as nutrient management or conservation tillage) is eligible for enrollment in the BMP Challenge program. Since many farmers will change two or more practices at the same due to implementing a systems based approach in their farming operation, we would like to enroll fields where farmers are implementing both a nutrient management change and a conservation tillage practice such as strip till.
2. **Install MRBI Demonstration Site**: AFT proposed to work with collaborating partners including established University of Illinois drainage monitoring sites to engage a farming operation to implement a systems approach to nutrient management. The demonstration site will generate field days and demonstrations for farmer outreach and education
3. **Install edge-of-field monitoring to track water quality on the MRBI demonstration site**: AFT proposed to build upon the success of and protocol of current and ongoing edge-of-field monitoring developed by University of Illinois researchers Mark David and Richard Cooke. Designed for the nutrient management system selected by the participating farmer, paired monitoring will be installed and monitored.

Methods

Utilizing a proactive, collaborative and multi-faceted approach, AFT identified the following strategies that were crucial to obtaining the desired outcomes : 1. **Engage a wide variety of partners and stakeholders** to form an effective and strategic project coalition to review plans and progress and to provide support in implementing deliverables; 2. **Overcome barriers to adoption by engaging agriculture to develop solutions**: To understand how to overcome barriers that hinder producers from more widely adopting conservation practices, AFT created a white paper, focusing on solutions to getting "late" adopters to act; 3. **Build ongoing support within the agriculture and fertilizer industries**: AFT engaged individuals in the target watershed as well as state agriculture leaders to both inform the project and simultaneously disseminate what is learned. 4. **Implement on-the-ground activities utilizing USDA MRBI CCPI funding in the Upper Salt Fork Watershed**: The project engaged farmers through our active relationships with independent crop advisers, Certified Crop Advisers, agricultural cooperatives, state and county agencies and watershed groups. 5. **Secure dedicated funding for and install monitoring sites**: Monitoring was a key component of the project and results of monitored fields was extensively shared with producers. This project had the benefit of building on the success of University of Illinois researchers, Richard Cooke and Mark David, who had for two years before the project began, been collecting baseline data in this sub-watershed and were about to commence monitoring sites for a subsurface tile and buffer tile project with cooperating producers who will be asked to share input costs and yield data. We expanded this data collection system and installed additional monitoring sites on cooperating producer fields who implemented nutrient reduction practices.

<u>Project Innovation</u>: The project was a proactive and collaborative approach in a volunteer setting, working one-on-one with farmers to advance their adoption of new conservation practices and fine-tune nitrogen management systems while ensuring that their adoption will not result in loss of yield and recognizing and promoting the economic benefits. It is a multi-faceted approach that will determine the barriers to adoption in the watershed, provide a roadmap for addressing those barriers, create demonstration sites to educate farmers, offer farmers multiple programs/tools to implement BMP's and, finally, includes a monitoring component to prove the effectiveness of the approach in improving water quality.

Producer Participation

AFT proposed that approximately 60 farmers (at an average of 80 acres each) of EQIP eligible producers will participate in the BMP Challenge by: (1) providing a basic nutrient management plan for participating acres; (2)providing nutrient application and/or reduced tillage equipment or custom tillage services as needed; (3) working with certified advisor or field representative to set up check strips within which they will implement their conventional tillage and nutrient practices; (4) implementing the nutrient management and/or CT practice on the balance of the field; and, (5) working with the certified advisor or field representative at harvest to compare and document yields from the check strip vs. immediately adjacent BMP-managed strips.

In addition, under our proposed CCPI effort, we indicated an aerial photo review of the watershed reveals about 66 active farmsteads. Some producers inside the watershed also farm outside the watershed and others outside the watershed farm within it. In total, therefore, we estimate approximately 100 producers are active in the watershed and potential participants in this project. By the end of three years, we estimated approximately 20% of acres in the targeted area will have active EQIP contracts for nutrient management and 10% of the acres will be signed up in strip-till practices.

Finally, we estimated 100-150 farmers per year will participate in workshops or attend field days held at the MRBI demonstration or other sites to learn more about implementing various BMPs and the results of our monitoring effort.

Project Action Plan and Timetable

Action	**Timing**	**Milestones/Deliverables**
1. Engage project coalition	July 2010 - Sep 2013	Identify project collaborators, gather input and refine/implement action plan
2. Overcome barriers to adoption	July 2010 – Mar 2011	Hold listening sessions; Develop white paper; complete a gap analysis; identify emerging practices and technologies; establish project website
3. Build ongoing support within the agriculture and fertilizer industries	July 2010 – Sep 2013	Form an agriculture advisory group
4. Implement USDA MRBI CCPI on-the-ground activities	Oct 2010 – Dec 2013	Project partners, field reps and crop consultants work with enrollees to implement BMPs
5. Install monitoring sites and continued monitoring	Oct 2010 – Dec 2010 Jan 2011 – Dec 2013	Install 2-4 monitored sites with cooperating farmers; Ongoing monitoring, testing and dissemination or results
6. Implement comprehensive outreach and education campaign	Mar 2011, 2012, 2013 July 2011, 2012, 2013	pre-planting information newsletters; case studies and field days and field demonstrations at selected farms and MRBI demonstration site
7. Enroll BMP Challenge participants	Mar - April 2011 Mar - April 2012 Mar - April 2013	60 farmers averaging 80 acres enrolled in BMP Challenge program
8. Yield and Net Returns Assessments	Sept-Nov 2011 Sept-Nov 2012 Sept-Nov 2013	Yield assessments performed and submitted to Agflex, guarantee payments made to farmers with reduced net returns
9. Document effectiveness of project activities	Nov-Feb 2011 Nov-Feb 2012 Nov-Dec 2013	Year-end survey of producers and suppliers, year-end and project final report on

		environmental impact (fertilizer reductions, erosion sedimentation reduction, GHG reductions and air quality improvements
10. Establish and operate MRBI demo site	Jan 2011 – Dec 2013	Recruit 1 producer to establish MRBI demonstration site
11. Project management and oversight	July 2010 – Dec 2013	Quarterly reports, conference calls, one annual meeting and final report

Project Management

Mike Baise—Director, AFT Midwest Regional office. Baise oversaw all project activities and coordination with our partners, and served as the key contact person for the project after the departure of Zurbrugg.

Jennifer Filipiak—Assistant Director, AFT Midwest Regional office. Filipiak assisted in coordinating with our partners and stakeholders.

Brian Brandt—Director, AFT Agricultural Conservation Innovations, Columbus, Ohio. Brandt coordinated AFT's on-the-ground *BMP Challenge* work in the watershed. Brandt has been with AFT for 10 years.

Dr. Ann Sorensen—Director, Research/Information, AFT's Center for Agriculture in the Environment, DeKalb, IL. Sorensen provided research and analytic support for the project.

Jimmy Daukas—Managing Director, AFT's Agriculture & Environment Initiative, Washington, DC. Daukas will oversee the project and its coordination with other related AFT efforts and political/agency leveraging for the project. Daukas has been with AFT 13 years.

Anita Zurbrugg—Former Project Manager and Assistant Director, AFT's Center for Agriculture in the Environment, DeKalb, IL. Zurbrugg will oversaw all project activities and coordination with our partners, and served as the key contact person for the project during her employment at AFT.

Jon Scholl—Former President, AFT, Washington, DC. Scholl provided strategic networking capabilities, based on his 30-year career in the State of Illinois Farm Bureau and as EPA's agricultural adviser.

The Champaign County SWCD along with NRCS staff and project consultants provided primary outreach and contact with farmers and sign up eligible farmers for MRBI EQIP funding. Special focus will be given to strategic selection of farm parcels for edge-of-field monitored sites and engaging producers to host monitored sites on these parcels.

Jonathon Manuel, Resource Conservationist, Champaign County SWCD
Bruce Stikkers, Former Resource Conservationist, Champaign County SWCD
Kevin Donoho, District Conservationist, USDA-Natural Resources Conservation Service Champaign Field Office

University of Illinois: The University of Illinois has a rich history of working with agriculture in Champaign County, home of the university**.** A group of researchers at the University of Illinois at Urbana-Champaign were funded in 2009 by the USDA CSREES National Integrated Water Quality Program. *The Salt Fork River Watershed Tile Modification Project, funded by USDA*

CSREES[1] builds on the water quality sampling that started in 2008 as part of the Salt Fork River Watershed Water Quality Monitoring Subcommittee and continued through 2013. The lead investigator is Mark David, a professor in the Department of Natural Resources and Environmental Sciences (NRES), with co-investigators Courtney Flint (NRES), George Czapar (Cooperative Extension), Richard Cooke (Agricultural and Biological Engineering, ABE). Mark David and Richard Cooke—who will be principal partners of AFT in the proposed project—have worked closely with The Champaign County SWCD and NRCS not only to implement the Salt Fork River Watershed Tile Modification project but also many others over the years. They have provided AFT and its other collaborating partners extensive technical guidance in designing the monitoring protocol for the proposed MRBI project and implemented the monitoring sites and ongoing measurements and evaluation.

Dr. Thomas Green, President, Agflex Inc. was responsible for BMP Challenge performance guarantee administration. Agflex (www.agflex.com) was formed in 2000 with capital from AFT and Iowa Dept. of Economic Development. Dr. Green has over 25 years experience in environmental protection and four successful ventures including an IPM supply business he grew to more than $1.6 million in annual sales and an independent non-profit (www.ipminstitute.org) that has won awards from US EPA three years in a row. Dr. Green published over 40 articles and presented at more than 60 professional meetings throughout the US and Canada. He holds a Ph.D. in entomology from the University of Mass. and is a Certified Crop Advisor and Technical Service Provider.

V. BACKGROUND

According to the U.S. Geological Survey, Illinois watersheds contribute the highest nutrient loads of the nine states responsible for 75 percent of the nutrient runoff that causes low-oxygen dead zones in the Gulf of Mexico. Reducing nutrient runoff is challenging in Illinois in part because of the high percentage of farmland and nitrogen-dependent corn production and the prevalence of shallow-tiled fields that quickly drain water from beneath the soil surface. Although advanced nutrient management practices could reduce the leakage and runoff of nutrients from fields, the concern that crop yields might drop is a potent barrier to adoption. Research has shown that practices such as, emerging fertilizer technologies, and shifting some or all fall nitrogen fertilizer application to spring applications can improve crop yields as well as reduce nutrient loading by 15 percent to 30 percent. .

In March 2010, AFT received funding from Walton Family Foundation for the first year of a three year project to work with producers and agriculture groups in Illinois through an innovative, multi-faceted approach to accelerate adoption of conservation practices that reduce nutrient runoff while maintaining crop yields. AFT consulted with key stakeholders across Illinois including IL NRCS State Conservationist; IL Resource Conservationist; Bureau of Water, IL EPA; Tom Jennings and Dennis McKenna, IL Department of Agriculture; and IL Farm Bureau and C-BMP,. We concluded that our best opportunity to significantly reduce nutrient runoff using AFT's strategic partnership approach and our *BMP Challenge* is in the The Upper Salt Fork River Basin and Spoon River branch of the Salt Fork Watershed, in Champaign County in east central Illinois.

[1] http://saltfork.nres.uiuc.edu/

The watershed had the advantage of having an established total maximum daily load (TMDL), a comprehensive watershed plan and a highly engaged watershed implementation committee. Within the Spoon River segment of the watershed, the University of Illinois was in the process of establishing monitoring sites at the edge of fields within sub-surface tile systems for a multiyear project and already had two years of in-stream monitoring data on which to build. This watershed is a priority area for the Mississippi River Basin Healthy Watersheds Initiative (MRBI).

8-digit focus area: 05120109
12-digit HUC sub watershed: 051201090303 Spoon River, 27,478.21 acres
Champaign County, Illinois

The planning activities preceding AFT's background work are contained in the 2007 *Watershed Implementation Plan for the Salt Fork of the Vermilion River*[2] report that was completed through a steering committee initiated by the Champaign County Soil and Water Conservation District. The Illinois Environmental Protection Agency also completed the TMDL process for the river at the same time. These documents describe the condition of the rivers in the watershed as well as make recommendations for remediation. Crop production is listed as one of the possible sources of pollutant loads into the stream. (Channelization is also listed as a source, but it will not be addressed by the project partners since it is part of prior history that has little chance of changing with any current efforts.)

[2] http://www.ccswcd.com/ShowFile.php?ID=33&file=salt%20fork%20reduced%20file%20size.pdf

The Salt Fork Implementation Committee, which started after the original steering committee members completed the report, began acting on the report's recommendations and, as a result of this effort to implement a comprehensive TMDL plan in the Salt Fork, both USDA CSREES and EPA invested in work by the University of Illinois and the Champaign County SWCD, respectively. This proposed project extends those early efforts with a plan, herein outlined, to effect significant application of conservation practices in the watershed. It is anticipated that the work of this project and the information generated, will be valuable in expanding acceptable practices to other watersheds.

The TMDL and watershed plan for this site stems from the productive soil and tile drainage that make this area some of the most productive farmland in the world. The tile that drains the excess water from the land also provides a conduit for naturally occurring soil nutrients such as nitrogen and phosphorus. This, coupled with the added fertilizer needed for crop production, can result in nutrients leaving the site and entering the streams that eventually carry it to the Gulf of Mexico.

The targeted area is near the top of the watershed, so the local goal has been to "start the streams clean," so they can flow south without adding unreasonably to the nutrient load. This also allows us to look at our practices and see what is likely to be most helpful in effecting reductions in nutrient runoff without interference from pollutants that originate long distances upstream from a site.

VI. REVIEW OF METHODS

Schedule of Events

From October 1, 2010 – September 30, 2011

- ***Engagement of agriculture groups***: AFT conducted outreach to the Illinois Fertilizer and Chemical Association; Illinois Corn Growers; NRCS State Conservationist; Champaign County Farm Bureau; the Illinois Department of Agriculture; Illinois Farm Bureau; and the Illinois Council on Best Management Practices (ICBMP)
- ***Communication with additional groups***: AFT conducted outreach on the project to many additional groups including the Illinois office of the Environmental Protection Agency (EPA); Howard Brown; GrowMark, AgriDrain and Agren; Iowa Soybean Association; the Sand County Foundation; The Conservation Technology and Innovation Center; Wes King, Illinois Stewardship Alliance; and similar county and state organizations from neighboring states of Indiana and Iowa.
- ***Participation in Nutrient Policy Roundtable***: AFT also engaged with the Nutrient Policy Round-table, formed as a result of the Nutrient Summit held on September 13-14, 2010 at the University of Illinois-Springfield. (See: http://www.epa.state.il.us/water/nutrient/index.html.)
- ***Participation in CTIC listening session***: AFT presented at the Conservation Technology and Innovation Center (CTIC) sponsored listening session with 22 farmers on the adoption of cover crops on December 9, 2010 in West Lafayette, Indiana.
- ***Participation in MRBI summits and workshops***: AFT participated in region-wide summits of watershed project managers, including from those projects funded by USDA MRBI, convened by Sand County Foundation in Lacrosse, Wisconsin on March 28-30, 2011 and by McKnight Foundation on June 1, 2011. The workshops resulted in participants prioritizing

issues and challenges within watershed projects, including NRCS MRBI funded projects. As a result of these meetings, AFT is working with Sand County Foundation, Iowa Soybean Association and Nature Conservancy to hold a workshop in November 2011 that will be focused on expanding and improving monitoring and measurements of results within MRBI watershed projects. Through these meetings, AFT and approximately 25 Upper Mississippi River Basin project leaders are focusing on improving watershed projects and finding ways to build support for continued federal and state funding for the USDA Cooperative Conservation Program Initiative, especially in the MRB.

- ***Cooperation with EWG***: AFT cooperated directly with the Environmental Working Group (EWG) in its efforts to assess projects receiving MRBI CCPI funding and to provide input into improving the MRBI CCPI program going forward. AFT used the pertinent issues identified in the draft assessment report EWG released internally, *The Mississippi River Basin Initiative: A Preliminary Review* (November 2010) as part of its Midwest Farm Bill listening session held in Sycamore, Illinois on March 18, 2011. At this workshop, AFT gathered input from 26 Midwest farmers on how to enhance the farm bill to improve conservation practices.
- ***Presentation at the Soil Water Conservation Society Annual Conference in Washington DC***: AFT organized a panel presentation at the SWCS conference, July 18, 2011. Three project managers from MRBI projects in Minnesota, Iowa and the Upper Salt Fork watershed project summarized their projects, shared early results and discussed lessons learned with 45 farmers, academics, SWCD staff, governmental officials and other policy makers.
- ***Produced and distributed multiple information newsletters****:* Funding for this project arrived in time in spring 2010 to allow AFT to work with its Champaign County partners to target farmers in the project area and provide timely spring fertilizer application information, address supply and application issues, and offer resources for support and answer questions. AFT worked with the Illinois Cooperative Extension Service and Project Partners to provide input to the area's farmers and farm organizations, and broadly distributed a producer pre-planting advisory newsletter which included planting and nutrient decision-making options. AFT also worked with the Champaign Soil and Water Conservation District (SWCD) to distribute two more mailings to encourage farmers in the area to take advantage of funding opportunities through this project, and with the USDA MRBI EQIP to help them fund the conservation practices farmers are willing to implement on their farms.
- ***Conducted survey of fertilizer supplier and continued outreach****:* Through the informal assessments provided by Jean Payne, Director of the Illinois Fertilizer and Chemical Association (IFCA), and our Champaign County partners, AFT confirmed that spring 2010 fertilizer demand was substantially up from years past and that 2009 fall application of anhydrous ammonia was significantly down. However, fall 2010 provided for an unusually early harvest resulting in ample time for fall application of nitrogen. The start to the 2011 growing season was a reminder of the fickleness of Mother Nature and likely inhibited spring application of N because of the extended wet weather, promoting a late planting season for farmers in much of Illinois.
- ***Conducted post-planting survey of producers and outreach (****completed locally)*: During the late summer 2010, AFT's Champaign County partners met individually with approximately 80 of the 100 producers in the watershed to sign up producers for Environmental Quality Incentives Program (EQIP) funding available through the USDA MRBI CCPI program, and they assessed producer interest in and use of nutrient management strategies on their farms.

- ***Tabulated results from project-specific producer survey questions**:* AFT ensured the inclusion of questions helpful to this project in a survey conducted by a University of Illinois researcher and partners, Mark David and Richard Cooke, along with Courtney Flint, Rural Sociologist with the University.
- ***Held producer workshops**:*
    - **Late Fall Workshop—**Partners held a workshop on November 19, 2010 with 18 farmers and agriculture retailers to update them on opportunities for their involvement in the project in the 2011 growing season.
    - **Winter Workshop—**Partners organized a Watershed Opportunities Workshop on February 22, in centrally located Royal, Illinois, attended by 23 farmers from the HUC-12 MRBI watershed project area. Project partners gave presentations on: 1) current challenges and successes in conserving our natural resources for Midwest agriculture; 2) opportunities for farmers with MRBI EQIP funds and BMP Challenge funds; and 3) establishing on-farm monitoring sites.
    - **Project Field Day—**On August 16, 2011, project partners and Dan Schaefer, an agronomist from Illini FS, assisted AFT in a bus tour with over 60 farmers from the Upper Salt Fork. Focusing on the topic of managing nutrients in fertilizer and conservation practices, the tour took participating farmers and others to two farm sites and the base of the Spoon River HUC 12 watershed. One of the farm sites included a paired monitoring site that involves three conservation practices, including a switch from fall to spring nitrogen application.
- ***Produced a white paper that includes recommendations on how to overcome barriers producers have that hinder more widespread adoption of conservation practices (draft completed but this is an ongoing effort and will be updated):*** AFT completed a draft white paper *The Adoption of Best Management Practices by Producers: Using What We Know to Get More Practices on the Ground in the Upper Salt Fork Watershed in Illinois*, based on the focused survey of project area farmers and a general literature review, as well as on information from a series of AFT listening sessions conducted with farmers across the country. Project partners shared the results with other watershed project managers and more broadly with stakeholders across the state to encourage more widespread adoption of conservation practices.
- ***Scaling up and "mainstreaming" the BMP Challenge yield guarantee tool:*** During this time period, AFT and partners worked with National NRCS staff at the highest level to secure approval by USDA of a yield guarantee program for conservation adoption based on the BMP Challenge model and funded through the general Environment Quality Incentives Program (EQIP). AFT and partners developed EQIP payment schedules and worked with state level NRCS staff in the Chesapeake Bay region. AFT proposed to NRCS to use the same approach in Illinois for its CCPI project. However, national level staff completed a guidance document that, effectively, prohibited the use of EQIP funding to cost-share BMP Challenge in its current form. This was a setback for overcoming farmers' "fear of yield losses" when adopting conservation practices that has been documented as a barrier to action. Fortunately, AFT had secured Conservation Innovation Grant (CIG) funds for the BMP Challenge in Illinois. As part of its efforts to introduce the existing BMP Challenge tool to producers and their advisers, on March 8, 2011 AFT hosted a webinar in the project area in Illinois. The webinar, *Targeted Application of the BMP Challenge in East Central Illinois and the Illiana Region*, was designed for potential BMP Challenge cooperators to learn the

basics of the program, including how we are targeting specific practices and producers with the BMP Challenge in Champaign County, Illinois and surrounding areas. AFT sent email invitations to certified crop advisers, NRCS staff, extension personnel and others in advance of the webinar. Due to the targeted nature of the webinar, we had 17 individuals attend the webinar. *In crop year 2011, we enrolled 2 farmers in the BMP Challenge.*

- ***Survey of BMP Challenge participants:*** Working with Agflex, our BMP Challenge partner, we conducted two BMP CHALLENGE surveys in 2011, one with farmers just completing the 2010 program, and one for participants from the years 2003-2009. Responses indicate that 87% and 79% of nutrient management participants from 2003-2009 and 2010, respectively, have continued the practice or a modified version on their fields. 100% of reduced tillage participants from 2003-2010 continued the practice through 2011 at least. In addition, 39% of participants enrolled in the program for more than one season, often adding a new BMP to their fields, and 97% felt that the methods used for the comparison of standard practices to BMPs was accurate and fair.
- ***Placement of stories in local print, online and radio***: AFT issued a news release announcing the launch of the project; conducted a radio interview with Gale Cunningham, Farm Director on WYXY 99.1 with the agreement to provide ongoing updates as appropriate; and provided support for Champaign County partners in two radio and newspaper interviews. In addition, AFT staff presented information on Ecosystem Markets and water quality issues and trading at the Agricultural Media Summit, and cultivated long-term coverage of the Champaign County project through interviews and discussion with editors and agriculture communicators in attendance. Five farmers participating in the project through implementing conservation practices were interviewed in May for radio and podcasts to be used on project's Web site.
- ***Developed project sell sheets.*** AFT developed two "sell sheets," one to promote farmers' adoption of monitoring sites and another to promote the BMP Challenge within the watersheds. These were distributed at the February 2011 workshop and the August 2011 field tour.
- ***Recruited farmers within the targeted CCPI watershed to implement nutrient management practices including the change from fall to spring nitrogen applications:*** During this time period, project partners recruited 13 farmers (out of a potential pool of approximately 130 in the watershed) to adopt conservation practices, of which three have committed specifically to switching from fall nitrogen application. At least five farmers implemented eligible practices but chose to implement the practices independently and outside of EQIP funding. These first year sign-ups were a result of a concerted effort by project partners from the Champaign County SWCD and the USDA NRCS Champaign Field office during the truncated sign-up period late in the summer of 2010. Participating farmers were able to choose from a suite of eligible practices chosen specifically for conditions to address water quality in the HUC-12 project area. Current data provided by the Champaign County SWCD include:
    - Total acreage signed up during this time period for practices: 6,108 (out of a potential 27,500 acres in the sub-watershed) for crop years 2011, 2012 and 2013. Practices applied fall 2010/spring 2011: 2,204.5 acres (2,130.1 nutrient mgt, 74.4 cover crops); approximately 486 acres, fall to spring application.
- ***Worked with researchers at the University of Illinois to develop a scientifically robust protocol and monitoring strategy and process to monitor and document producer practices and nutrient and other inputs and nitrates loss. This strategy will include the minimum and ideal number of monitoring sites****:* AFT's partners completed the protocol for monitoring sites within the project area and have established two sets of monitored sites. One of the challenges in the watershed is to not only find willing farmers to participate, but to also find sites

that stand up to the robust protocol required of reliable monitored sites. Project partners secured participation from multiple farmers to conduct monitoring on 10 tiles on four farms in the Salt Fork watershed.

Farm (1) contains a pair of pattern tiles draining land in continuous no-till corn/soybean since 1985.

Farm (2) contains a pair of pattern tiles draining land in conventional corn/soybean.

Farm (3) contains three irregular tiles draining approximately 300 acres of land in strip-till corn/soybean since 1992. This farmer side-dresses fertilizer N.

Farm (4) contains two pattern tiles draining approximately 80 acres of land in conventional corn/soybean. This farm also contains an irregular pattern tile draining approximately 60 acres of continuous corn.

This research will provide important feedback on N fertilizer management under various production systems that is not possible by any other process. It is much easier to run a model than collect data, but models are only as good as the empirical data that was used to calibrate them. These monitoring sites will be producing valuable information from which farmers and researchers will benefit.

From October 1, 2011 – September 30, 2012

- ***Secured 22 CCPI/EQIP contracts with farmers to adopt new conservation practices***: AFT contracted with a retired fertilizer retailer and utilized a new promotional piece to promote EQIP practices in advance of the final 2012 EQIP deadline of June 1. Because of this effort and an offer to cost-share fall soil testing, 26 farmers sought EQIP applications for new conservation practices. Due to documentation difficulties, however, only 18 received new contracts. However, an additional four farmers signed up for cover crops or strip tillage practices for a total of 22 new conservation contracts covering more than 4,230 additional watershed acres. The EQIP sign-ups resulted in 10 basic nutrient management, 6 enhanced nutrient management, 3 cover crop and 3 strip tillage contracts.
- ***Promoted cover crops during field day in August 2012:*** AFT and the Champaign SWCD held a field day in August for watershed farmers that focused on cover crops. While this practice is not generally used in the USF, it has proven to be effective in addressing soil health and water quality improvements in other places. The Champaign SWCD Board determined that cover crop planting is an area of interest and has made it a county priority. This interest coincided perfectly with the project's watershed goals and Bruce Stikkers (Champaign SWCD) identified several cover crop suppliers who were interested in promoting cover crops in the USF. Dr. Mike Plumer (Illinois Council for Best Management Practices) presented a comprehensive program on cover crop selection and management for USF soils and local conditions. In addition, AFT began working with the National Wildlife Federation on the policy aspects of promoting cover crops in Illinois.
- ***Secured support of key state and local agricultural leaders and groups for conservation practice benchmarking:*** AFT secured support from the following farm groups regarding the need for benchmarking conservation practices: the Illinois Council on Best Management Practices (which includes Illinois Farm Bureau, Illinois Corn Growers Association, Illinois

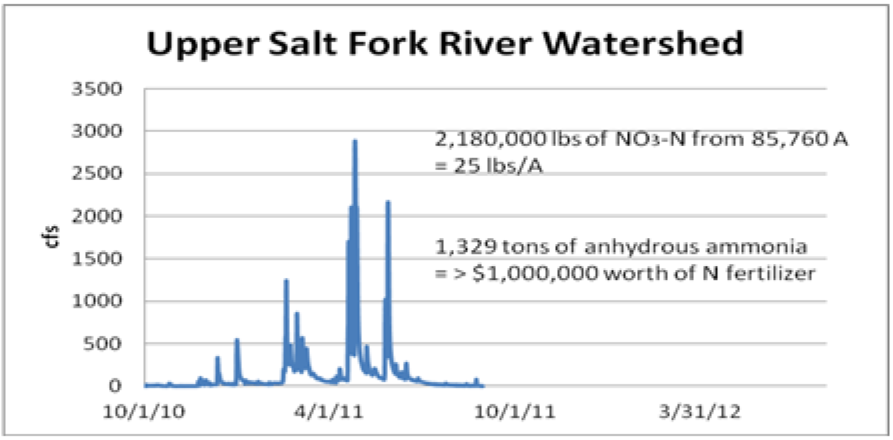
Soybean Association, Illinois Pork Producers, Illinois Fertilizer and Chemical Association and Syngenta Crop Protection); Illinois Corn Marketing Board; University of Illinois Cooperative Extension Service; and, the Champaign County Farm Bureau. AFT, Reetz Agronomics and PAQ Interactive have been working together to collect and organize watershed data of existing farming practices and conservation efforts for the USF project. Phase 1 of this effort involved the gathering of all existing available information on the watershed's physical conditions, including soil maps, topography, surface drainage systems, streams, roads and infrastructure, property lines, land uses, wetlands, and visible conservation practices from aerial photos. These data are captured in a database and will be complemented by personal farmer interviews and surveys to be done in Phase 2. Farmers will be asked to supply information about cropping systems, nutrient management, yield data, and tiling systems.

- ***Shared lessons learned from USF on monitoring, measurement and benchmarking with other projects in the Mississippi River Basin (MRB):*** AFT, the Iowa Soybean Association, The Nature Conservancy and the Sand County Foundation convened project managers from Iowa, Illinois, Minnesota, and Wisconsin in November 2011 in Ankeny, Iowa to discuss the most cost-effective means of documenting progress on their respective water quality projects. The USF project leaders presented project updates and shared lessons learned with other MRB project leaders and conference participants at the meeting of the Soil & Water Conservation Society in July 2012 in Fort Worth, Texas. Building on the success of the 2011 MRBI watershed project meeting in Iowa, AFT (along with the Sand County Foundation, The Nature Conservancy and Iowa Soybean Association) is planning a second meeting of regional MRB project leaders in late October 2012 in Ankeny, Iowa.
- ***Coordinated with new effort to engage women landowners in the USF***: During the project, AFT identified the need to work with absentee landowners (many of whom are women) as a potentially effective means of expanding adoption of conservation practices. Approximately 50% of farmers in Champaign County lease additional land, many from female absentee landowners. Thus, AFT co-sponsored a "learning circle" on conservation practices for women landowners on April 16, 2012. While this event was funded by other sources, it leverages the work being funded by USDA and the Walton Family Foundation (WFF) by generating strong interest in conservation practices in the broader watershed. At the April event, AFT provided information on conservation practices to 21 women in Champaign County through informal discussions (in a casual "circle") and a bus tour to observe implementation of actual practices. As a result of the workshop, at least 11 of the 21 women have committed to exploring the use of cover crops or other conservation practices on the farmland they own. The workshop participants own 7,700 acres of farmland or 3% of the acres in the county. AFT believes that success in engaging absentee landowners, especially women, will help accelerate practice adoption and is continuing to reach out to this important segment of owner/operators. Based on the strong interest in cover crops expressed by the women attending the April event, AFT convened a second Champaign County learning circle in Royal, Illinois in the morning of August 17, which was followed by an afternoon workshop on cover crops sponsored by AFT. Sixteen women landowners from Champaign and Vermillion Counties participated in both the learning circle and workshop. Another conservation-oriented learning circle for an additional 16 women in Bureau County was held August 28 and planning is underway for an additional circle for Coles and Douglas Counties

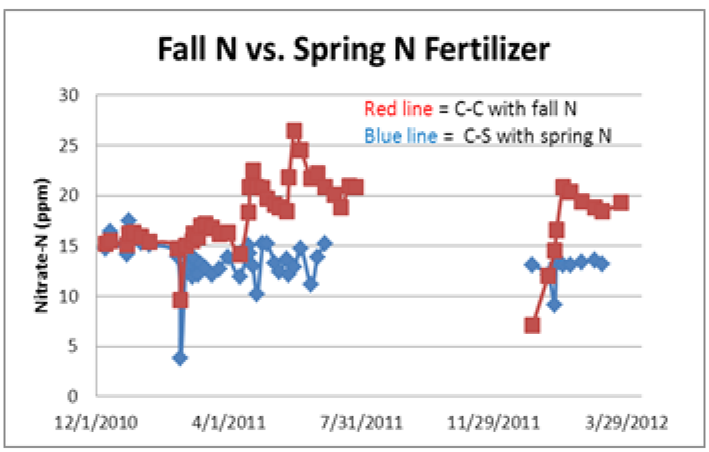
(East Central Illinois) in the spring of 2013. These events are a result of the resounding success of the USF learning circles and lessons learned in the watershed.

- ***Producer and landowner cover crop workshop***: AFT sponsored a cover crop workshop on August 17 in Royal, Illinois. The focus of the workshop was technical information and recommendations on cover crop planting and management. Mike Plumer, a well-known cover crop expert and former University of Illinois Extension crops expert, was the featured speaker. There were 38 farmers and landowners that attended the workshop.
- ***Leaders in the agricultural community support improved farming practices***: Farmers indicating interest in serving on the AFT-USF Advisory Committee and publicly supporting the project include: Todd Hesterberg and Norm Rademacher from Ogden; Dennis Huls from Urbana; Doug Bluhm, Mitch Osterbur and Les Olson from St. Joseph; Russell Buhr from Gifford; and, Michael Babb from Penfield. All of these individuals are considered to be "thought leaders" who can influence their peers.
- ***Engage two agricultural retailers in the project area to recruit and enroll farmers in the BMP Challenge:*** Ehler Brothers Fertilizer supports USF nutrient management practices and BMP. Illini FS, Inc. is interested in the BMP Challenge program, but has experienced management changes during the reporting period. AFT will connect with Illini FS soon to gauge their interest and potential support. AFT has contracted with a local agricultural consultant to promote the BMP Challenge program. He will be working with a retired local fertilizer salesman and local ag retailers to identify up to ten farmers who he will work with to implement improved nutrient practices on their farms. Using proven nitrogen testing protocols, the consultant will show farmers that they can lower nitrogen rates along with better application methods and timing and maintain or improve crop yields. The consultant will focus on helping the farmer to implement practices and will enroll the farmer in the BMP Challenge, if desired.
- ***BMP Challenge enrollment, feasibility analysis and cost reduction strategies***: AFT and its partners were not successful in enrolling any producers in the BMP Challenge program in crop year 2012. Despite one-on-one outreach and presentations at various meetings over the last two years, producers were not interested in the BMP Challenge in the USF watershed. Also, AFT completed a feasibility analysis of the BMP Challenge program that identified two primary cost-reducing strategies. The first is to focus on advanced BMPs. Greater precision in achieving nitrogen reductions will reduce the costs of the BMP Challenge because overall reductions in N-loss can be achieved while maintaining or even increasing yields—thus decreasing pay-outs. The second strategy is that scaling up the program would provide significant program savings as field costs per acre decrease with additional acres enrolled. The analysis also determined that BMP Challenge program costs are most dependent on corn prices. AFT's offer to help cost-share various soil testing regimes (including nitrate-N testing) will help farmers make better decisions regarding nitrogen applications for the 2013 crop year. Farmers that reduce nitrogen applications based on nitrate-N testing results and enroll in the BMP Challenge program should experience better results compared to farmers that are not using the nitrate-N testing programs.
- ***Continuation of Monitoring:*** Current monitoring data is shown in the following two graphs. Spring N application plus corn-soybean rotations continue to out-perform continuous corn. This past winter (2011/2012) was warm and tile nitrate reached 20 parts per million (ppm) two months earlier in continuous corn than the previous year. Fortunately, the lack of rainfall in spring 2012 limited tile flow and river N loads. Monitoring continues to reflect an average

loss of 25 pounds of N for every acre in the watershed, except in areas where conservation practices have been applied.



Since October 1, 2010, nearly 2.2 million pounds of nitrate-N were exported from the Upper Salt Fork River Watershed at St. Joseph, Illinois. This watershed consists of 85,760 acres—of which approximately 90% of these acres are in either corn or soybean each year. This amount of riverine N represents a loss of 25 pounds of N for every acre in the watershed. In terms of fertilizer value, we estimate the total N loss during this timeframe to be equal to more than one million dollars of anhydrous ammonia (based on $800/ton).



The figure above shows nitrate-N (ppm) for two tiles draining either continuous corn with fall N fertilizer application or spring N application in a corn/soybean rotation. This past winter was warm and tile nitrate reached 20 ppm two months earlier in continuous corn than the previous year. Fortunately, the lack of rainfall this spring has limited tile flow and river N loads.

<u>From October 1, 2012 – September 30, 2013</u>

- ***USF-AFT Advisory Committee:*** On February 19, the Upper Salt Fork (USF) Advisory Committee met to discuss the content and format of the project work plan for crop year 2013, including producer outreach for EQIP practices and targeting for cover crops and other practices. The purpose of the USF Advisory Committee is to advise USF project partners on project strategies and work plans.

- ***Conducted one-on-one outreach and distributed multiple information newsletters:*** AFT is using an SWCD contractor to make personal contacts in inviting farmers to this event. An informational mailing to 130 watershed farmers on EQIP sign-ups was sent in March. A second mailing went out to farmers and landowners in June. Benchmarking information from farm/land characteristics and the input of local fertilizer dealers is being used to develop general targeted areas for standard EQIP practices
- ***2013 CCPI/EQIP contracts***: Despite the extensive outreach efforts, the number of 2013 MRBI EQIP contracts lagged expectations with 8 contracts on 578 acres. Based on feedback from from the USF Advisory Committee and farmer feedback, paperwork and late payments continue to discourage farmers from applying to EQIP.
- ***Conduct workshops and field days***: Project partners organized two meetings/field days in 2013. First, project partners hosted a nutrient management/cover crop workshop on June 28th with 74 attendees. Second, the University of Illinois held an educational field day co-sponsored by AFT which focused on in-stream and edge of field monitoring on August 20th, 2013. Third, AFT co-sponsored a statewide cover crop conference in Decatur, Illinois on January 29-30, 2013. More than 250 farmers and SWCD and NRCS staff attended the meeting.
- ***Continuation of monitoring***: Our University of Illinois partners continued to monitor both edge-of-field and in-stream for watershed water quality measures. Due to the very dry late summer, edge-of-field measurements are generally not indicative of changes in practices during this grant reporting period. AFT partners continue to seek watershed farmers with good paired drainage sites. University researchers have found significant reductions in paired drainage sites when cover crops were utilized on one side and absent from the other side.

  Currently, the U of I is monitoring the flow and nutrient loading in 10 tiles in the watershed. Water quality samples are collected proportionally to flow rates, i.e., more flow, more samples. Water samples are analyzed to determine concentration of nitrate or phosphorus throughout each flow event. This allows researchers to determine total pounds of nitrate-N or phosphorus lost. In addition to edge-of-field measures, the U of I and the USGS added a second gauge to the Spoon River in the watershed with real time nitrate sensing to better understand N dynamics in the watershed.

  Also, last year's dry conditions during the growing season limited corn yield and N uptake and large amounts of N remained in the fields unused. U of I researchers designed an experiment using a paired tile system in the watershed to test the ability of cover crops to absorb unused N and reduce potential N loss through tile drainage. One tile field received a cover crop mix of annual ryegrass and radishes aerially seeded on September 8th and the other paired tile field was left bare. By November 8th the cover crop above ground biomass accumulation of nearly 1 ton per acre contained more than 50 lbs of N per acre and reduced tile nitrate loss by about 50%. In the spring of 2013 the cover crop was given an N credit of 30 lbs. per acre. Results from the fall of 2013 will show if and how crop yields and nutrient efficiency were affected. A variety of weather events has made it more difficult to draw conclusions about watershed practices and water quality during the past three years, but has underscored the necessity for longer term data collection.

- ***Shared lessons learned from USF on monitoring, measurement and benchmarking with other projects in the Mississippi River Basin (MRB):*** Under the framework of the Leadership for Midwestern Watersheds (LMW), AFT and other entities that are leading MRBI projects have been meeting since 2011 periodically to exchange information and share lessons learned about project design and implementation with the goal of improving performance of watershed projects in the Midwest. These include, but are not limited to projects that receive funding from the USDA's Mississippi River Basin Initiative (MRBI). The latest LMW meeting was held last year in Ankeny, Iowa on October 31 and November 1. The participants from the Ankeny meeting represented watershed projects from Iowa, Minnesota, Wisconsin, Indiana and Illinois; 13 of these were new participants. A new item for this session was a pre-meeting survey aimed at providing direction for the meeting discussions. Survey respondents provided input on the subject areas that were discussed at Ankeny: Engaging farmers, targeting conservation practices and scaling up lessons learned from watershed projects.
- ***Cover crop cost share opportunity for USF farmers***: Due to very little interest in the BMP Challenge program and low enrollment in MRBI EQIP contracts, AFT decided to also offer a watershed cover crop incentive through the Champaign SWCD using resources from the Illinois Department of Agriculture, AFT and other non-USDA partners. This program was designed to be easy for the farmer to apply/enroll with only a one page application required to sign up. This approach proved to be more effective in getting farmers to try cover crops, resulting in 12 USF farmers planting cover crops on 1,495 watershed acres. In addition, farmers were willing to accept $15/acre, instead of $27/acre as offered by EQIP. This cover crop incentive program is an effort by AFT to test other incentive payments/programs that will be easier and faster for farmers to enroll in and will expedite payment after the practice is implemented. The Champaign SWCD had a prior incentive effort for strip till that used a very simple application, enrollment and payment process that was very successful. We will be using that model to incentivize cover crops and, potentially, a side dress nitrogen practice.
- ***Technical expertise opportunity for USF farmers***: A certified agronomist/certified crop adviser was retained by AFT to reach out to operators in the project's targeted area. Not all farmers in the watershed are interested in enrolling in EQIP or other USDA conservation programs to help them implement conservation practices on their farms. In response, we are partnered with a local crop consultant company, Cropsmith, Inc., to identify five early adopter and five late adopter farmers that they can work with to guide implementation of both basic and advanced nutrient management practices.
- ***BMP Challenge enrollments***: AFT worked with CropTech, an IL ag retailer and consulting company, to enroll 7 farmers in eastern Illinois in the BMP Challenge program. Those seven farmers implemented the Adapt-N tool developed by Cornell University on 348 acres of corn in 10 different fields of approximately 40 acres each. Agflex, our BMP Challenge partner, handled the administration of the BMP Challenge enrollments.

<u>From October 1, 2013 – September 30, 2014</u>

- ***USF-AFT Advisory Committee:*** In November 2013, the USF Advisory Committee recommended that cover crop adoption be a primary work emphasis for 2014. The committee believed that AFT was in a strong position to successfully promote cover crop use as an element within a larger nutrient management strategy.

- ***Outreach and communications***: In this reporting period, AFT/Champaign SWCD communications with USF farmers to promote EQIP, SWCD cover crop and toolbar (nutrient management) incentive promotions included three mailings to 130 USF farmers for advanced practices and more than 1,000 postcards to all Champaign County producers.
- ***Conduct workshops and field days***: AFT/Champaign SWCD held "Roots for Improvement 3" field day on March 14, 2014, in Homer IL on cover crop selection and termination practices with 31 producers attending. A second field day was held June 20, 2014 in the USF with 70+ attendees to observe aerial seeding and field test strips of cover crops and nutrient management practices.
- ***Targeting of fields and practices***: In the Spring 2014, USF watershed fields were identified through a combination of the benchmarking tool and IL Department of Agriculture/Champaign SWCD transect survey data. AFT/SWCD conducted a second additional transect survey to gain additional field observations of cropping practices for targeting purposes.
- ***Cost share opportunities for side dress equipment and cover crops:*** In general, Champaign County farmers were still reluctant to participate in the EQIP program in 2014. This was likely due to several factors, including continuing delays with the pending Farm Bill (at that time) and the uncertainty of funding. Because burdensome applications and late payments early on in the grant period continued to discourage farmers in the USF from applying to EQIP, AFT and the Champaign SWCD developed a short, easy application and an expedited incentive payment process for the cost share program.

  First, it was learned through the Advisory Committee that there was considerable interest of Upper Salt Fork watershed farmers in moving from fall N application to try split fall-spring applications and spring-side dress applications. But the shortage of proper equipment (by fertilizer retailers) to help the farmers make these applications was an obstacle that was not anticipated. AFT and Champaign SWCD combined resources to assist in the lease of the appropriate toolbar equipment for six producers in the USF project area through a competitive application process. Each of these six producers that were funded committed to an annual minimum of 500 acres of spring or side-dress N applications for a three-year period. The total acreage commitment each year for all of the producers is nearly four thousand acres and the producers will report the acreage side dressed for each of the next three years. The SWCD estimates that this incentive will cost $15 per acre over the three-year period. We should also note that there was also very strong response to an AFT/SWCD toolbar lease-purchase incentive – to the point that the incentive budget for toolbars was expended quickly. We have learned through Champaign SWCD that there are at least 15 additional farmers in the watershed that are interested in purchasing side dress applicators.

  Second, AFT and Champaign SWCD repeated the cover crop cost share program implemented in 2013 that resulted in 12 USF farmers planting cover crops on 1,495 watershed acres. In 2014, the Champaign SWCD program resulted in 34 farmers planting cover crops on 2,958 reported acres. NRCS reported 415 acres of EQIP cover crops contracts.

- ***Technical expertise opportunity for USF farmers***: In 2013 and 2014, AFT retained Cropsmith, a local agronomic consultant, to reach out to targeted farmers based on benchmarking and transect field observations. None of the farmers expressed interest in cost shared soil testing. Cropsmith's certified professional agronomist attended the watershed field days and workshops and personally contacted targeted farmers in the watershed and offered free soil testing and nutrient recommendations. None of the farmers expressed interest, even when the service would be provided at no charge to them. The SWCD contractor personally contacted targeted USF farmers with an offer of the BMP-Challenge yield guarantee and none accepted this offer. Targeted letters were sent out by Champaign SWCD to USF producers but there were no responses to the letter. Therefore, there were no BMP Challenge enrollments in 2014.
- ***Salt Fork Watershed Implementation Committee***: In 2014, AFT participated on the Salt Fork Implementation Committee, a sub-committee of the Champaign County SWCD. The committee is charged with developing the conservation measures needed to reach conservation goals. The sub-committee met on November 6, 2014 and will meet again on February 5 and April 2 in 2015.
- ***Shared lessons learned from USF on monitoring, measurement and benchmarking with other projects in the Mississippi River Basin (MRB):*** A planning and review LMW meeting was held in Dubuque, IA on February 13, 2014. The group decided that the LMW can effectively convene the community of watershed management practitioners in the Midwest and produce papers on what is working or not in watershed management. In addition, a group of the LMW met at the 2014 Soil and Water Conservation Society meeting in Lombard, IL in July 2014 to discuss next meeting logistics and survey participants with subject matter of interest.
- ***Survey of BMP Challenge participants**:* Working with Agflex, our BMP Challenge partner, we completed an additional survey of 2013 BMP CHALLENGE participants. The survey yielded similar results to the 2011 survey with 72% reporting they will continue to use the BMP or a modified practice on an average of 67% of their acres in 2014.

VII. DISCUSSION OF QUALITY ASSURANCE

Detecting Field Scale Changes Through Edge of Field Monitoring

Detecting changes in tile drainage losses of nitrate and phosphorus or surface runoff of phosphorus in response to management changes or conservation practices is very challenging. Ideally, paired fields are chosen with the same operator, soils, production methods, and crop, and instrumented to constantly measure flow, with water samples collected proportionally to flow (as flow increases more samples are collected) using automated samplers. These water samples are analyzed in a laboratory using standard analytical methods to determine the concentration of nitrate or phosphorus (both reactive and total) throughout each flow event. Average concentrations are calculated along with the calculation of total pounds of nitrate-N or phosphorus lost from the field. Ideally, the paired fields are monitored with identical practices for several years, then implement the change, and monitor for several more years. This would be repeated with 3-5 sets of pairs, to have confidence that the changes are real and broadly applicable.

What often happens is that monitoring data can't be collected before the changes are made, and an assumption is made that the two fields would have had similar nitrate and phosphorus losses. Again, if several pairs respond similarly to the management or conservation practices, it is safe to have confidence in the result. If even one year (or spring) of monitoring data before changes are made could be obtained that alone would help to better understand the response.

In the Spoon River watershed in the Upper Salt Fork in Champaign County, the area is quite flat and is heavily tile drained, with nearly all cropping corn and soybeans. In this area tile and stream flow can increase very rapidly, making continuous tile water flow measurements a requirement to know what the loss is. In other studies tiles have been monitored with flumes, but these do not give reliable data at times, because the tile outlet can be submerged at high flow and the water level can back up. The University of Illinois partners developed a system that uses a V-notch weir for low flow readings, with a pressure transducer to measure the water depth behind the weir. At higher flows a magnetic flow meter is used, which works very well for high flow measurements, even if the outlet of the tile is submerged. Data loggers are also used to record the readings from these two devices, and obtain high quality tile flow measurements on an interval of 15 minutes. SIGMA automatic samplers are installed that can hold up to 24 samples. These collect water samples as a function of flow, and then these water samples are analyzed for nitrate using ion chromatography, and for reactive and total phosphorus using a Lachat colorimetric analyzer. The autosamplers are set to sample more than needed to understand how concentrations change during a flow event, as unneeded samples can be thrown aways. Sampling frequencies are adjusted accordingly for the targeted nutrient as needed.

To measure surface runoff, it is required to have a field where most surface flow is directed towards one low spot/outlet from the field. At this location a flume is installed and usually metal wing-walls to direct flow into the flume. The flume can be instrumented to measure flow as well as to allow for automatic sample collection. Samples are again analyzed for phosphorus.

Watershed Scale Nutrient Losses

At the watershed scale, such as for the upper Salt Fork watershed, continuous flow measurements and automatic sample collection from the river are needed. For our watershed, the USGS measures flow at a gage north of St. Joseph, Illinois. At least weekly samples or more are taken to measure the nitrate and phosphorus concentrations, depending on flow of the river.

BMP Challenge Program

Farmers were enrolled in the program based on their eligibility for EQIP programs. Many farmers were recruited through existing relationship with a crop advisor trained in administering the BMP CHALLENGE program. Sites were located in eastern Illinois, in and near the Upper Salt Fork watershed.

Sampling Design: All measurements of yield, agricultural inputs, etc. were rounded to the nearest hundredth. Moisture levels were measured to the nearest tenth of a percentage and moisture factors to the nearest ten-thousandth.

We believe that the size of comparison strips and efforts to ensure accuracy yields results comparable to real-life cropping practices. In a 2011 survey of growers who participated in the program, 97% felt that the experimental setup and comparison of Check Strip to BMP Strips was accurate and fair.

Procedures: Crop advisors and growers were provided with recordkeeping forms and an instruction packet detailing experimental setup, implementation and data collection methods at the time of enrollment. Specifically, crop advisors were contractually obligated to provide a preseason management plan detailing tillage and/or nutrient inputs at all stages of crop development for the comparison of BMP and grower's standard practice.

Crop advisors tracked inputs and costs and reported per acre nutrient and/or tillage expenses. They recorded observational differences in lodging, weed pressure, population and N deficiency in pre-harvest field assessments. Finally, growers and crop advisors recorded individual yields and moisture content for the grower's standard strip versus the two adjacent BMP comparison strips.

Measurements recorded onto worksheets by crop advisors were shared with the BMP CHALLENGE project coordinator or assistant. The coordinator or assistant then manually entered this data into excel spreadsheets and extrapolated economic losses or gains and environmental benefits over the entire field, communicating with crop advisors and farmers when questions of accuracy arose. These net return calculations were reviewed by Thomas Green and Brian Brandt for accuracy.

Quality Control: Some have criticized the comparison of a single check strip versus two BMP strips because the lack of replication does not allow us to analyze variance and determine statistical significance in yield differences. Our project team worked with a statistician to determine that our check vs. BMP strip layout is yields comparable results to replicated trials. Our design is easier and cost-effective for growers to implement, and the level of accuracy is adequate for farmers to compare practices and make an informed and risk-free decision to implement a BMP.

BMP CHALLENGE incorporates many safeguards and standards to provide an accurate comparison between the grower's standard practice and the BMP. Crop advisors made every effort to locate the Check Strip and adjacent BMP Strips in a uniform portion of the field. At the outset, advisors identified, marked and recorded the locations of BMP and Check strips with flags, GPS and/or landmarks. If possible, they avoided areas that have variable soil types, slopes, irregular boundaries and variable fertility and/or tile lines running parallel to the row.

If it was not possible to avoid non-uniform areas, crop advisors took the following measures:

(i) If a slope, rocky area or any other feature disrupted field uniformity, strips were placed so they run across the non-uniformity affecting the Check Strip and adjacent BMP Strips equally.
(ii) If the field had a small outcropping or a depression, strips were placed on one or the other side of these features.
(iii) If the field had two or more soil types, strips were placed so they crossed the different soil types at right angles, affecting the Check Strip and adjacent BMP Strips equally.

(iv) If the enrolled acres were in contour strips that were not wide enough to contain both a Check Strip and two adjacent BMP Strips, one strip was selected that best represents the productive capabilities of the covered acres and that is appropriate for use as a Check Strip. The contour strip was split in half and the grower applied the BMP rate of fertilizer on one half of the contour Strip and the grower's standard on the other half. Alternatively, the crop advisor could place the Check Strip in one contour strip and the BMP Strips in immediately adjacent contour strips, provided the three contour strips were reasonably uniform and representative of the balance of the field.

The schematic below illustrates the general layout of each field:

BMP also implemented here.	At harvest, yield on the Check Strip will be compared to the yield on one or both of the immediately adjacent BMP Strips.
Adjacent BMP Strip	
Check Strip – Apply grower traditional practice here	← Check Strip = 40' to 80' wide
Adjacent BMP Strip	← BMP Strip= same size as Check Strip with an equal number of rows as the Check Strip
BMP also implemented here.	
← Strips run length of field (exclude end rows) →	

VIII. FINDINGS

Project Accomplishments

- ***MRBI/EQIP acreage enrolled***
  - Total acreage signed up during 2010 and 2011 for practices: a total of 13 new conservation contracts covering 6,108 (out of a potential 27,500 acres in the sub-watershed) for crop years 2011, 2012 and 2013. Practices applied fall 2010/spring 2011: 2,204.5 acres (2,130.1 nutrient mgt, 74.4 cover crops); approximately 486 acres, fall to spring application.
  - Total acreage signed up in 2012 for practices: a total of 22 new conservation contracts covering more than 4,230 additional watershed acres. The EQIP sign-ups resulted in 10 basic nutrient management, 6 enhanced nutrient management, 3 cover crop and 3 strip tillage contracts.
  - Total acreage signed up in 2013 for practices: a total of 8 new contracts on 578 acres.

- ***AFT and Champaign SWCD cost share program acreage enrolled***
  - The cover crop cost share program implemented in 2013 resulted in 12 USF farmers planting cover crops on 1,495 watershed acres.

- The cover crop cost share program implemented in 2014 resulted in 34 USF and Champaign County farmers planting cover crops on 2,958 reported acres. NRCS reported 415 acres of EQIP cover crops contracts.
- The sidedress toolbar cost share program implemented in 2014 resulted in the lease of the appropriate toolbar equipment for six producers in the USF project area through a competitive application process. Each of these six producers that were funded committed to an annual minimum of 500 acres of spring or side-dress N applications for a three-year period. The total acreage commitment each year for all of the producers is nearly four thousand acres and the producers will report the acreage side dressed for each of the next three years.

- ***BMP Challenge:*** The total acreage enrolled in the BMP Challenge program during the project period was 412 acres. 12 fields were in enrolled in the BMP Challenge by 9 farmers implementing nutrient management practices (PSNT and Adapt-N). The goal for the grant was to enroll 5,250 acres with 60 farmers in the BMP Challenge program. We completed significant outreach through one-on-one contact, field days and workshops, targeted mailing, webinars, etc. Unfortunately, farmers in the USF were not interested in enrolling acreage in the BMP Challenge program. We have not been able to pinpoint the reason farmers in this watershed have not been interested at all in the BMP Challenge. Probably many of the factors that impacted enrolled acreage in EQIP in the project area are the same factors that impacted enrollment in the BMP Challenge.

- ***MRBI Demonstration Site and Edge of Field Monitoring:*** Two paired monitoring sites implemented through CIG and private project funding are currently producing results in the project area. AFT had hoped to establish four more monitoring sites (two paired sites). Since farmers are not eager to use EQIP funding for monitoring sites on their farms (or other practices), the project relied partly on alternative funding for monitoring sites and ongoing monitoring costs. The university continues monitoring the flow and nutrient loading from a total of ten field tiles in the watershed at edge of field sites. Samples are collected proportionally to flow rates. Water samples are analyzed to determine the concentration of nitrate or phosphorus throughout each flow event allowing measures of total pounds of nitrate-N or phosphorus lost.

  In addition to edge-of-field measures, the university and the U.S. Geological Survey added a second gauge to the Spoon River in the watershed with real-time nitrate sensing. The second in-stream gauging station will increase water quality data from different branches of the Salt Fork. This addition will be useful especially since in dry late summer, edge-of-field measurements are generally not indicative of changes in field practices during the cropping season. The second gauging station should assist researchers in making comparisons of nutrient sources beyond edge of field and within whole watershed monitoring.

  Based on data gathered from our paired sites, the U of I partners found significant reductions in paired drainage sites when cover crops were used on one side and absent from the other side during the previous crop season. The experiment used a paired tile system in the watershed to test the ability of cover crops at absorbing unused N and reducing N loss through tile drainage. One tile field received a cover crop mix of annual rye-grass and radishes aerially seeded early in September and the other paired tile field was left bare. By early November, the cover crop biomass accumulation of nearly one ton per acre contained more than 50 pounds of N per acre and reduced tile nitrate loss by 50%. This research contributed to the USF Advisory Committee and the Champaign SWCD goal of accelerating cover crop adoption and offering a cover crop seeding incentive for 2013 and 2014.

- ***Establishment of Leadership for Midwestern Watersheds:*** Under the framework of the Leadership for Midwestern Watersheds (LMW), AFT, Sand County Foundation, the Iowa Soybean Association, the Iowa Chapter of the Nature Conservancy and others that are leading MRBI projects have been meeting since 2011 periodically to exchange information and share lessons learned about project design and implementation with the goal of improving performance of watershed projects in the Midwest.

  Extensive meeting proceedings and executive summaries are produced for each meeting and shared among an LMW list-serve. LMW meetings have focused on different aspects of watershed practices and sharing of what works or not among meeting participants. The group has determined that the LMW can effectively convene the community of watershed management practitioners in the Midwest and produce papers on effectiveness of various watershed management strategies, seek to bring more partnerships to watershed management and make others aware of partnership opportunities in the new Farm Bill – especially RCPP.

Project Obstacles and Lessons Learned

The most notable obstacle faced by the partners during the grant period was the unwillingness of some farmers in the USF to even try elementary nutrient management -- even if it is offered as a free service. It is increasingly apparent that some farmers will not respond to any best management practice incentives – and change in behavior may need to be driven by a regulatory measure.

Another significant obstacle was that farmer "ownership" of the project in the Upper Salt Fork area was more of a challenge than originally anticipated. Although due in part to the culture of the farming community in the area, the delay in EQIP funding to launch farmer sign-ups for the 2010 crop year also delayed and hampered outreach with farmers and therefore impacted the number of EQIP sign-ups in subsequent years and, potentially, farmers willingness to implement monitoring sites. The establishment of the USF Advisory Committee in 2012 significantly improved the outcomes in 2013 and 2014. We were able to solicit direct feedback from farmers in the watershed about their concerns, interests in various practices and approaches that might be more successful. Their input led to the focus on cover crops and to our specialized incentive programs for cover crops and side dress applicators that used an expedited application and payment process.

A survey of farmers in the Upper Salt Fork watershed completed during the project period may explain why some farmers are unwilling to try new practices and, also, were unwilling to take "ownership" of the project.

> *Results of surveys of producers in the Salt River Watershed:*
> *In the spring and summer of 2010, our collaborators at the University of Illinois interviewed 40 farm operators and landowners (including four drainage commissioners) as part of the project in the Salt River watershed to address nitrate losses by modifying*

drainage tile lines. They also mailed a survey to 306 farm operators in July 2010 (the names were obtained from the Farm Security Agency through the Soil and Water Conservation Districts) and received 82 back for a 31 percent response rate (considered normal) (David et al 2011).

Survey responses indicated that most producers in the Upper Salt Fork think water quality conditions are good. Forty four percent thought it was very good and 16 percent thought it was excellent. However, it appears that producers associated the question about water quality with drinking water, not with the Salt Fork River. When asked about their level of concern about water quality, most were concerned primarily with drainage rather than the quality of runoff. They are more concerned with water standing in the fields when they get heavy rains. Indeed, 82 percent of the respondents indicated that their fields need more drainage. Neither size of farm nor farm income made any difference to their perceptions of conditions or concern about water quality. When asked to identify sources of water quality problems, the top four sources were sediment, municipal discharges, nitrogen and phosphorus but many didn't know. Even the top sources of water quality problems were not considered serious problems. Only 17.3 percent thought nitrogen was a severe problem and 13.5 percent thought phosphorus was a severe problem.

As mentioned previously in the report, during the first year of the grant, AFT was successful in contacting nearly 90% of the 130 farmers living in the Upper Salt Fork watershed to inform them about the project. During that year, 13 farmers (about 10% of farmers in the watershed) committed to using USDA cost-share funds to adopt conservation practices for Crop Years 2011-2013. The total acreage committed to conservation practices was slightly over 6,000, with participating farmers using nutrient management, cover crops, and fall-to-spring fertilizer applications. Unfortunately, AFT was not able to build on the initial success to add new farmers in the second and third years of the project. Three obstacles affected AFT's ability to do so: 1) a delay by NRCS in paying farmers during Year One; 2) a transition in AFT project management that delayed the reassessment of strategies and affected outreach during the winter of 2012; and, 3) high corn prices. Details on these are described as follows:

NRCS delayed its scheduled payments to farmers under the initial EQIP contracts because of an internal misunderstanding regarding how to handle EQIP projects in the Mississippi River Basin Initiative program and word about significant delays in payments spread across the watershed. While AFT resolved the delay issue in a meeting with state NRCS staff in September of 2011, it had already become a focus of attention for producers in the watershed and began to discourage additional farmers from applying for EQIP funds. As a result, concerted and intensive outreach to farmers by AFT and its partners was needed to overcome the existing negative perceptions of EQIP funding and to lay the groundwork for a smooth relationship moving forward.

Anita Zurbrugg, AFT's project manager and Midwest Region Director based in Illinois, resigned from AFT in October of 2011 after nine years to take a position with a community foundation near her home in Illinois. AFT then reassigned its Research Director to manage the project in the interim period. After a national search, AFT hired Michael Baise, a highly qualified agricultural specialist and project manager. His career includes 12 years in program and management positions with the Illinois Department of Agriculture and 15 years with the Indiana Farm Bureau as an advocate for agricultural and natural resource issues. AFT met several times with project partners during the search process and it was clear that a strategic reassessment of strategies was needed. As a result, outreach to farmers was on hold during the winter. When Baise started at AFT in January 2012, he immediately spearheaded this reassessment. By bringing a fresh perspective, Baise reenergized the partnership and developed promising new approaches to hasten progress towards the outcomes.

High commodity prices made conservation payments less attractive. Commodity prices were very high during the project period. Farmers make their planting decisions based on the expected returns on their production decisions. The USF watershed has some of the most productive soils in the country, with corn yields frequently averaging at 200 to 230 bushels or more per acre yields. Using prices received during the project period and expected yields, USF farmers could reasonably expect gross returns to corn planting to be in the range of $1,250 to $1,435 per acre. These attractive returns on production decisions may make the EQIP payments of $10 to $40 per acre and the work to participate in the BMP Challenge program appear to not be worth the effort. To compound matters, the paperwork required to qualify for EQIP payments is more complex and time-consuming than the process used for Farm Services Agency commodity supports. The farm data submitted by producers to qualify for payments is not shared between programs, which forces the farmers to re-enter their data. Local soil and water conservation district (SWCD) and NRCS partners have told AFT that the EQIP application process is a major deterrent, especially in relation to the financial incentive being offered for practice adoption.

There were also several other issues that were recognized as barriers to engaging farmers and convincing them to utilizing the BMP Challenge program and/or the NRCS EQIP program in the USF project. These issues include:

Timing of NRCS conservation practice deadlines frequently occur after farmers have made their management decisions**.** In January 2012, NRCS added a new practice to its suite of approved nutrient management options, which would pay farmers to switch from their fall nitrogen (N) application to the spring, or to split their N applications of spring and side-dress to the growing crop. While this created a new nutrient management opportunity for improved N applications, it came well after many farmers in the watershed had fall-applied their nitrogen for the spring 2012 corn plantings. Fortunately, one of the major fertilizer retailers in the watershed (Ehler Brothers Fertilizer) does not offer fall anhydrous ammonia applications. The company expressed strong interest in this new opportunity and agreed to work with AFT's partners to promote the practice because their entire customer base would be potentially eligible. AFT partners strategized with Ehler Brothers to promote the new nutrient management practice. However, good weather thwarted this opportunity. The mild winter and early 2012 spring caused Illinois farmers to begin planting preparations earlier than normal. Thus, spring N applications were well underway before the NRCS signups could be promoted to potentially eligible farmers in the watershed.

Cash-rent tenants with annual leases are less likely to sign up for conservation practices. Another factor that influences the use of conservation practices is the issue of land ownership and the opposing interests of cash-renters versus landowners. The competition for rental acres in Illinois is fierce, with cash rents being pushed upward by the value of commodities. Anecdotal information on cash rents in central Illinois points to a range of $300 to $400 per acre. Farmers who cash-rent land on an annual basis have little incentive to participate in conservation practices that will yield little or no financial incentive. A University of Illinois survey of the USF project determined that approximately 70% of the farmers were farming predominantly on rented land.

The 2012 drought created uncertainty for USF producers. The crop year of 2012 will long be remembered for its extended period of high temperatures and little rain. Champaign County received spotty and generally insufficient rainfall during June and July of 2012, severely affecting the corn crop. Soybean development was also affected, but late rains saved several areas of the county from extreme crop failure. The lack of moisture during the growing season also is documented in the USF monitoring data collected by the University of Illinois. 2012 will be an aberration from recent water quality trend-lines for nutrient losses during the growing season. However, there is likely to be interesting data from the unutilized nutrients in subsequent monitoring as rain events recharge soil moisture levels and field tiles begin to flow again. One effect of the drought is the increased interest of USF farmers in cover crops, specifically their ability to scavenge and retain nutrients not utilized by the crops during the growing season.

Finally, the key lesson learned from the continuing monitoring work in the watershed is that seasonal weather events make it difficult to draw conclusions about watershed practices affecting water quality. The diversity in weather during the past three years has underscored the need for long term data collection efforts to support technically sound conclusions.

IX. CONCLUSIONS AND RECOMMENDATIONS

The project team identified several recommendations regarding the development and implementation of a comprehensive watershed project such as the one implement by AFT and partners in the Upper Salt Fork watershed in Champaign County, Illinois. The recommendations include:

Planning and Development

1. Work through an advanced watershed planning process to identify strong partners, to understand baseline levels of conservation and environmental outcomes in the watershed, to identify needs of farmers and to identify critical and sensitive areas in the landscape where funding should be targeted.
2. Establish partnerships prior to seeking funding.
3. Develop partnerships that play to each other's strengths and bring a specific skill set or expertise to the project.
4. Develop non-jurisdictional agreements (MOU's) to help define the roles of the partners and provide a template for moving the project forward.
5. Ensure that there is local "ownership of the project by:

a. Establishing a strong group of local stakeholders that includes a significant presence from the agricultural sector. Convene the stakeholder group at least quarterly and incorporate their feedback in the entire development and implementation process.
b. Identifying and cultivating strong, committed, local (County, SWCD, etc.) leadership to help drive the project.

Implementation

1. Hire a strong, full-time coordinator to lead the project. Ideally, the coordinator would not have responsibilities outside of the watershed project, therefore the sole focus of the coordinator would be on the project.
2. Develop a farmer led advisory committee for the project to help drive potential actions by farmers and to help get the right kind of adoption in order to make measurable improvements in water quality.
3. Develop and implement a communication plan to:
    a. Get the message out that good things are happening and progress is occurring in the watershed.
    b. Effectively communicate scientific information so that all stakeholders understand the impact of changes at the farm level on environmental outcomes taking place in the watershed.
4. Develop and implement a strong monitoring plan that will:
    c. Be able to measure performance and outcomes of changes made by farmers in the watershed. This should include monitoring activities at both the farm and watershed scale.
    d. Process monitoring data quickly so that farmers can use it to make management decisions on the farm.
    e. Provide appropriate information to the project partners so that an adaptive management process can be utilized to make any changes that may be needed or desired.
5. Incorporate an adaptive management process into the project plan so that outcomes can be monitored continuously and mid-stream corrections can be implemented quickly.

X. APPENDICES

Appendix A. USF Project Fact Sheet

American Farmland Trust
SAVING THE LAND THAT SUSTAINS US

Working with Farmers in Illinois to Adopt Nutrient Management Practices
Project Fact Sheet
March 2012

American Farmland Trust (AFT) is embarking on a strategic, three-year project to reduce nutrient runoff in the Upper Salt Fork watershed in Champaign County, Illinois and engage agriculture leaders and groups to leverage the work throughout the state.

Purpose

According to the U.S. Geological Survey, Illinois watersheds contribute the highest nutrient loads of the nine states responsible for 75 percent of the nutrient runoff that causes low-oxygen dead zones in the Gulf of Mexico. Reducing nutrient runoff is challenging in Illinois in part because its high nitrogen-dependent corn production and the prevalence of shallow-tiled fields that quickly drain water from beneath the soil surface. Although advanced nutrient management practices could reduce the leakage and runoff of nutrients from fields, the fear that crop yields might drop is a potent barrier to adoption. Research has shown that practices such as pre-side dress nitrogen testing, variable rate application and shifting from fall to spring fertilizer application can reduce nutrient loading by 15 percent to 30 percent with little or no yield impact. Almost 75 percent of Illinois producers traditionally apply fertilizer in the fall but the cool and wet growing season in 2009 forced most to postpone fertilizer application to spring, creating a ripe opportunity to change timing of application. Fertilizer suppliers and applicators have had to build capacity to meet this unusual demand and will be waiting to see if farmers decide to continue spring application after this growing season. This project includes strategies to maximize support for this transition.

Goal

AFT seeks to improve the health of water quality in the Mississippi River Basin by permanently reducing nutrients leaving agriculture lands in Illinois. To achieve this goal, AFT will work with producers and agriculture groups to accelerate adoption of conservation practices that reduce nutrient runoff while maintaining crop yields. AFT will work with its partners in the Upper Salt Fork watershed to demonstrate a replicable model. Over three years, we will: 1) Produce a 10 percent to 20 percent reduction in nutrient runoff on participating farms in the Upper Salt Fork watershed; 2) Convince farmers on 25 percent of the corn acreage in the sub-watershed to adopt new advanced nutrient management practices including a shift to spring fertilizer application; and 3) Develop a sustainable plan for scaling up this approach to the state and Basin levels.

Target Watershed and Project Partners:

AFT consulted with key stakeholders across Illinois including Bill Gradle, IL NRCS State Conservationist; Richard Hungerford, IL Resource Conservationist; Marcia Willhite and Amy Walkenbach, Bureau of Water, IL EPA; Tom Jennings and Dennis McKenna, IL Department of Agriculture; and Nancy Erickson, IL Farm Bureau. We concluded that our best opportunity to significantly reduce nutrient runoff using AFT’s strategic partnership approach and our *BMP Challenge* is in the Spoon River sub-watershed of the Illinois Upper Salt Fork in east central Illinois (http://saltfork.nres.uiuc.edu/Salt_Fork_map.html). Approximately 80 percent of the tile-drained highly productive farmland in this watershed is in row crop production. Committed partners in this effort include: Bruce Stikkers, Resource Conservationist Champaign County Soil & Water Conservation District; Kevin Donoho, District Conservationist, Champaign County, USDA NRCS; Mark David and Courtney Flint, Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign; George Czapar, University of Illinois Extension; Jean Payne, Illinois Fertilizer and Chemical Association; Brad Uken, Champaign County Farm Bureau; Salt Fork Watershed Implementation Committee; Illinois BMP Council, a coalition of agribusinesses, agricultural organizations and University of Illinois Extension; Harold Reetz, Consultant; and Tom Green, President, Agflex, Madison, WI.

Strategy and Activities:

- **Engage an Effective Project Coalition and Developing Strategies with all Stakeholders:** AFT will engage a wide variety of partners and stakeholders to form an effective and strategic project coalition.

- **Overcome Barriers to Adoption by Engaging Agriculture to Develop Solutions:** To understand how to overcome barriers that hinder producers from more widely adopting conservation practices, AFT will conduct a series of listening sessions with producers and create a white paper, focusing on solutions to getting "late" adopters to act; complete a gap analysis to identify new barriers that may have resulted from expanded ethanol markets, significant price fluctuations, increases in leased land and greater unpredictability of weather; explore new tools including AFT's *BMP Challenge*; and work with key state agricultural groups to produce a pre-planting information newsletter, surveys of fertilizer suppliers, post-planting surveys of producers, case studies of producers who have successfully switched to spring application, and information and outreach workshops.

- **Scale-up and "Mainstream" the *BMP Challenge* Yield Guarantee Tool**: The *BMP Challenge* is a crop yield guarantee that helps accelerate adoption of conservation practices by overcoming the barrier of real or perceived risk of a yield loss. The tool covers the key initial period when farmers are learning and implementing a best management practice (BMP). Although many farmers fear that BMPs may impact crop yields and income, 60 percent of farmers who try them actually save production costs with little or no negative effect on yields. As a result, about 60 percent of the farmers who use the *BMP Challenge* system adopt the BMPs because they turn out to be profitable. AFT and Agflex are working with USDA's Natural Resources Conservation Service (NRCS) to utilize the Environmental Quality Incentives Program (EQIP) to support large-scale use of conservation guarantee tools to help late adopters overcome the risk-of-adoption barriers. AFT also is gathering data about the yield and income impacts of many of newer, advanced nutrient management practices so they can be added to the *BMP Challenge* coverage. The ability to enroll advanced practices in the *BMP Challenge* also will have a significant impact outside of the project area.

- **Build Ongoing Support within the Agriculture and Fertilizer Industries:** AFT will apply lessons learned in the Upper Salt Fork Watershed to other counties and watersheds. AFT will form an agriculture advisory group that draws from individuals in the target watershed as well as state agriculture leaders to both inform the project and simultaneously disseminate what is learned.

- **Implement an On-the-Ground USDA funded CCPI Project in the Upper Salt Fork Watershed:** One of the immediate priorities is to secure federal funding through the Cooperative Conservation Partnership Incentive (CCPI) to help farmers shift from fall to spring fertilizer application and adopt advanced nutrient management practices. The plan of action likely will include: 1) Engaging farmers through our active relationships with independent crop advisers, agricultural cooperatives, state and county agencies and watershed groups; 2) Enlisting crop consultants, extension and conservation district staff to recruit farmers, oversee on-site work, and/or act as third-party verifiers; 3) Providing farmers with yield/income guarantees so they will change their practices; and 4) Expanding the *BMP Challenge* to include advanced nutrient management practices such as in-season testing and nutrient application.

- **Install Monitoring Sites:** Monitoring will be a key component of the project and help convince producers applying fertilizer in the spring is worth considering as a routine part of their operations' suite of BMPs. Results of monitored fields will extensively be shared with producers. This project has the benefit of building on the success of University of Illinois researchers, Richard Cooke and Mark David, who have for two years been collecting baseline data in this sub-watershed and are about to commence monitoring sites for a subsurface tile and buffer tile project with cooperating producers who will be asked to share input costs and yield data. We will expand this data collection system to other cooperating producers who may implement the *BMP Challenge* or participate in a CCPI project.

PROJECT CONTACTS

Mike Baise—Project Manager and Contact, AFT Midwest Director, Bloomington, IN. Baise will oversee all project activities and coordination with partners mbaise@farmland.org or (317) 508-0756

Brian Brandt—Director, AFT Agricultural Conservation Innovations, Columbus, Ohio. Brandt will coordinate AFT's on-the-ground *BMP Challenge* work in the watershed (bbrandt@farmland.org) or 614-430-8130

Appendix B. BMP Challenge Fact Sheet

American Farmland Trust
SAVING THE LAND THAT SUSTAINS US

BMP Challenge – East Central Illinois

Project Goal for 2011

Acres: +/- 1500 acres
 # Producers: +/- 20
Field size: 40-100 acres (multiple fields possible)

Eligible Practices (to compare with producer's current practice)	
No Till/ Reduced Till	Any variation that retains at least 30% residue (no-till, conservation till, strip, ridge, etc.)
NMP Basic or Enhanced Implementation	Fully implement plan to manage amount, source, placement, and timing of nutrients.
In/post season tests (PSNT,CSNT, chlorophyll meter)	Test results determine N rate for total or side-dress applications.
Minimum Disturbance, Incorporation, Injection	Total N application based on efficiency value of manure incorporation.
Nitrogen Inhibitor/Enhanced N products	e.g. ESN, Agrotain
Sensor-based variable rate application	Side dress rate determined at time of application with variable rate equipment.

Timing and Tasks

NOW!! to March	• AFT & Advisors identify participants/practices, sign consultant agreement • Advisor enrolls producers/sign agreements • Producer and Advisor plan the BMP implementation & fill out Field Info Form
April – June	• Planting • Check strips identified and plotted using protocol ➔send in Check Strip Form. • Final fertilizer applied and verified
August – November	• Farmer notifies advisor of intended harvest • Producer and advisor together harvest strips and complete Yield Assessment Form ➔send in Yield Assessment Worksheet. • Guarantee payments made to producers (December)

Benefit to Farmer

- AFT pays for time working with a certified consultant
- Program includes an in-field comparison for learning
- Reimbursed for full value of net loss in income (yield – savings in fertilizer or fuel)
- NOTE: In the event of an economic profit, BMP CHALLENGE requests farmer contribute 1/3 of the gain back to the program (up to $6 per acre) so other farmers can participate.

Advisor Payment rate

- $8 per acre enrolled in BMP Challenge

American Farmland Trust
SAVING THE LAND THAT SUSTAINS US

Targeted Application of the BMP Challenge in East Central Illinois and the Illiana region

Join us for a Webinar on March 1

REGISTER NOW

Space is limited.
Reserve your Webinar seat now at:
https://www2.gotomeeting.com/register/447724114

Agriculture represents one of the most cost-effective ways to improve water quality. With high levels of nutrient runoff from Illinois watersheds, Best Management Practices (BMPs) used by farmers can positively impact the environment and, when done right, also improve the farmer's bottom line. Our BMP Challenge is a crop yield guarantee that helps farmers adopt conservation practices by overcoming the barrier of risk. Learn the basics of the program and more about what we are trying to do with the BMP Challenge in Champaign County, Illinois by attending this free webinar on March 1, 2011.

Title:	*Targeted Application of the BMP Challenge in East Central Illinois and the Illiana region*
Date:	Tuesday, March 1, 2011
Time:	9:00 AM - 10:00 AM CST

After registering you will receive a confirmation email containing information about joining the Webinar.

American Farmland Trust

Background on the BMP Challenge

What it is: BMPC is a system designed to assist agricultural agencies/advisors recruit producers who, so far, have not adopted certain BMP practices because of their concern that they will lose income as compared to their usual system. This tool can be especially valuable in watersheds where a high degree of participation is necessary to reach resource protection goals.

How it works. A farmer who wants to adopt a BMP is provided with a) the technical assistance to implement the BMP, b) a system for measuring the success of the BMP, and c) a guarantee that during the adoption period s/he will not lose income caused by his adoption of the BMP.

How it was developed: The BMPC system was developed through the NRCS Conservation Innovation Grants program where its technical and financial components have been thoroughly reviewed and approved in the CIG process in two different grants. It has been used on over 15,000 acres.

What it is not. The BMPC system is not insurance. Technically it is called a "service agreement." (It is like the guarantee that accompanies a termite treatment. The treatment is very effective but the agreement helps give the purchaser peace of mind). It only covers losses related to BMP adoption. It covers **net losses** (yield losses minus any savings in fertilizer or equipment use).

Eligible Practices: BMP Challenge can be used with numerous practices based on priorities of the farmer, his/her advisors, and state and federal agencies. The best are practices that, a) producers would like to try but haven't gotten "off the fence," and b) a fear of foregone income is a key barrier.

Below are a number of practice options that are eligible for 2012. Additional input is welcome.

1. **Reduced tillage**: Includes any variation that retains at least 30% residue (no-till, conservation till, strip, ridge, etc.
2. **Nutrient Management Basic** - Plan Implementation (Managing amount, source, placement, form, and timing of the application of plant nutrients and soil amendments) NOTE: includes full crediting of available manure N.
3. **PSNT** Base final N application on in-season soil test. Assumes the second application > than the first.
4. **CSNT:** Basing N application on post season stalk test.
5. **Minimum Disturbance Incorporation of manure** (e.g., vertical tillage, field cultivator. Assumes lower N rate on BMP Portion)
6. **Manure Injection** (e.g., sub surfer. Assumes lower N rate on BMP portion)
7. **Nitrogen Inhibitor/enhanced N products** (e.g., slow release)
8. **Sensor-based variable rate application** (Crop Circle, Green Seeker)
9. **Others**? (need to be UI/NRCS approved)

The *<u>OPTIMUM CANDIDATE</u>* is when an advisor (peer, consultant, extension, district, NRCS staff) sees a match between a producer and a practice that could benefit their operation but they are still "on the fence."

Appendix C. USF White Paper: The Adoption of Best Management Practices by Producers

The Adoption of Best Management Practices by Producers
Using what we know to get more practices on the ground
in the Upper Salt Fork Watershed in Illinois
American Farmland Trust Center for Agriculture in the Environment
May 2011

All agricultural practices impact the environment. For example, soil loss and erosion can reduce crop yields and impair natural and manmade water systems while runoff of nutrients applied to farm fields can contaminate groundwater and surface waters. By using conservation practices, farmers can minimize most of these impacts but many occur off-site (or downstream) and their impacts on crop yields may not be significant enough for farmers to take action. Data is difficult to come by but a conservative attempt to quantify the external costs of agricultural production in the U.S. puts those costs at $5.7 to $16.9 billion annually (Tegtmeier and Duffy 2004).

USDA's Economic Research Service (ERS) estimates that 829 million acres (80 percent of our croplands, pasturelands and rangelands) need conservation practices to control wind and water erosion, prevent nutrients and pesticides from reaching waterways, enhance wildlife habitat and improve grazing lands (Claassen et al. 2007). Although it is hard to determine how much of that land is currently protected by conservation practices, the runoff of nutrients and sediments from farmland continues to impair water bodies nationwide (Dubrovsky et al 2010). Many farmers install practices on their own and those practices are rarely tracked. For example, in 2001, roughly 37 percent of farm operators had either retired cropland from production or had installed working-land conservation structures (e.g. riparian buffers). Of these, a third had used conservation payments.

Recent analyses from USDA's Conservation Effects Assessment Project present the clearest picture to date of the need to get more conservation practices on the ground. In the Upper Mississippi River Basin, conservation practices have reduced the loss of soil sediments by 69 percent, total nitrogen (N) loss by 18 percent and total phosphorus (P) loss by 49 percent. But the analysis also shows that the combination of practices in use by farmers is often inadequate to address excessive losses of both soil sediments and nutrients. In short, 62 percent of the cropped acres (36 million acres) require additional treatment to reduce the loss of nitrogen or phosphorus from farm fields and 15 percent (8.5 million acres) remain critically undertreated with highly erodible soils and soils prone to leaching (USDA NRCS 2010). In the Chesapeake Bay, conservation practices have reduced edge-of-field sediment loss by 55 percent, losses of N with surface runoff by 42 percent and in subsurface flows by 31 percent and losses of P by 41 percent. However, 19 percent of cropped acres (810,000 acres) remain critically undertreated and additional conservation on these acres could lead to further reductions in soil, N and P loss between 25-37 percent (USDA NRCS 2011).

The BMP adoption process

In 2006, the USDA NRCS Social Sciences Team analyzed over 2,500 research reports on how farmers adopt best management practices (BMPs) or conservation practices and summarized their results (USDA NRCS 2005). They conclude that Rogers' Adoption-Diffusion model remains the most commonly used process for "getting conservation on the ground." Rogers laid out six stages that producers commonly go through in adopting a practice: Awareness of the problem; Interest in more information; Evaluation (how the technology can be applied to the producer's operation; Trial (testing the applicability at a specific site); Adoption (full use of the technology); and Adaptation (producer customizes the practice or technique to fit his or her needs). Producers get their information from different sources as they progress through each stage (USDA NRCS 2005). In Stages 1 and 2 (Awareness and Interest), producers turn to mass media, government agencies, friends and neighbors, dealers and salespeople (in that order). In Stages 3-5 (Evaluation, Trial and Adoption), farmers rely on friends, neighbors and family; government agencies; mass media; dealers and salespeople. And in Stage 6 (Adaptation), farmers use their own personal experience. In addition, producers are increasing turning to the Internet and certified crop consultants as sources of information.

In 2006, recognizing that adoption may be based more on subjective perception than on objective truth and that producers expect BMPs " will allow them to better achieve their goals," the adoption blueprint was refined (Pannell et al, 2006). In this slightly modified version, the stages of adoption become:

1. Awareness of a relevant opportunity on one's own farm.
2. A process of data collection of positive perceptions of a practice.
3. Their own cautious trial evaluation. Without a small evaluation, chances are greatly diminished for adoption.
4. Scaling up the innovative practice, a continuous process that sometimes is only a partial or modified adoption.
5. A continuous process of review and modification.
6. Dis-adoption when not sufficiently encouraging or goals are not advanced. This could lead to abandonment or a scaling down of the practice.

Rogers also recognized that farmers adopt new practices at different rates and he characterized these groups as: innovators, early adopters, early majority, late majority and laggards, each with their own value systems, personal characteristics, communication sources and social relationships (USDA NRCS 2005). Of these groups, the early adopters rather than the innovators tend to be the most respected "opinion leaders" in the agricultural community because they are more cautious in their approach and tend to gather information on the reliability of a technology before they proceed. These producers can help others adapt to change.

More recently, the "laggards" or "late adopters" have come under greater scrutiny. The recent USDA CEAP analyses show that 15 percent (8.5 million acres) in the UMB and 19 percent (0.8 million acres) in the Chesapeake remain critically undertreated with highly erodible soils and soils prone to leaching, requiring treatment for multiple natural resource problems (USDA CEAP analyses 2010 and 2011). These acres can contribute disproportionately to water quality problems. For example, eight of 61 farms in the Pleasant Valley watershed in Wisconsin occupy only 12 percent of the area but are responsible for 73 percent of the estimated runoff of phosphorus. Avoiding the "late adopter" and "bad actor" terminology, Nowak instead characterizes these eight farms as opportunities and potential collaborators (Nowak 2010). Although they are engaging in inappropriate behaviors in vulnerable times or places, it is up to us to listen to them and mutually develop solutions that work (Nowak 2010).

In most watersheds, reaching the producers on critically undertreated acres and getting conservation practices on their land will be a challenge and projects will have to figure out the best approach for that particular watershed. For example, AFT and its partners convened listening sessions with conservation professionals, agricultural retailers and producers in the Sandusky River watershed in Ohio. By reaching out to key stakeholders, we were able to determine that fertilizer dealerships and their affiliated certified crop advisors are in the best position in this watershed to identify and work with farmers who are engaged in inappropriate behaviors.

Along with understanding the process farmers typically go through on the way to implementing a BMP, it is also helpful to identify and address the obstacles in their way. AFT typically holds listening sessions with producers and conservation professionals in a watershed to determine these barriers but surveys can be equally effective. The USDA NRCS Social Science Team (USDA NRCS 2005) highlight many of the common obstacles to adoption:

- Farmers may not be aware of or understand the on-site and offsite causes and consequences of their farming practices, the short and long term benefits of conservation and the types and sources of available assistance.
- Farmers may worry that the adoption of practices may reduce crop yields or they may lack appropriate management skills.
- Community constraints may include the absence of support from leaders, family, friends and neighbors and the absence of active community support structures such as conservation districts, salespeople or local USDA offices.
- Organizational barriers may include conflicting messages from different sources, confusion over the roles and responsibilities among the various agencies and lack of coordination between and among agencies.
- Economic obstacles may include lack of cash or credit for producers share of cost and limited cash flow while waiting for government reimbursement.
- Landlord-tenant relationship issues may include short-term leases that may discourage installation and maintenance of practices/systems and program sign ups that may require long term commitments.

And once projects understand these obstacles, they can ask farmers the best ways to overcome them. For example, The USDA NRCS Social Science Team (USDA NRCS 2005) particularly recommends:

- Use local information sources to promote conservation;
- Seek out and work with early adopters and use them to demonstrate BMPs to the rest of the community;
- Use demonstrations, pilot projects and field tours to showcase BMPs;
- Use community support structures such as environmental education programs and centers (*AFT Note: this could be very effective for reaching out to absentee landowners who live in the watershed*);

- Use “Conservationist of the Year” programs, active watershed coalitions and “Ag Days” to help reinforce and shape the diffusion of a technology.

Nowak also suggests paying land users in small watershed a proportionate incentive for working together to solve local conservation problems. He points to the tillage clubs in the 1970s and pasture walks in the 1980s that involved groups of neighbors who came together to successfully promote BMP adoption (Nowak 2009).

Predicting Adoption
In general, the voluntary adoption of best management practices (BMPs) occurs slowly and producers adopt practices that protect the environment more slowly than technologies and practices that increase crop yields and productivity and respond to market demands Nowak et al., 1997; Marsh 1998)). Hundreds of studies both in the U.S. and other countries have looked at the adoption of BMPs by farmers and tried to use the information gathered to improve adoption rates (Makuch et al., 2004). A research analysis of international literature extracted nearly 170 variables that can influence farmers’ adoption of BMPs but none are universally significant (Knowler and Bradshaw 2006). Of the variables identified, education, farm size, income, rainfall, extension/technical assistance, program participation and awareness of environmental threats show mostly positive correlations.

A similar review in the U.S. of 55 studies over 25 years also finds that none of the adoption variables are consistently positive or stand out (Prokopy 2011). The author concludes:

- Capacity measures can be easily surveyed and include acres, education, farming experience, income capital and land tenure:
    - Education is more likely to have a positive impact.
    - Capital and income are mostly positive (but capital is often insignificant).
    - Income is never significant for landscape management and water management BMPs.
    - Mixed evidence about the role of farmer experience.
    - Mixed evidence about the role of land tenure.
- Proximity to rivers does not lead to higher rates of adoption.
- Social networks appear to be important.
- Increased awareness and increased information are important.
- Farmers who perceive a practice will be profitable are more likely to adopt (but if they have used cost share dollars to adopt one practice, they will not necessarily continue to use cost share programs to adopt subsequent practices).
- Farmers who are more likely to adopt BMPs are younger, have larger acreages, higher education levels, more income and capital, more diverse operations, and more access to labor.

Reading through the studies, it becomes apparent that management complexities (time commitment and expense) and profitability are key factors impeding further adoption of many BMPs. Farms of all sizes tend to adopt management practices that are profitable and provide environmental benefits without large conversion costs (e.g. conservation tillage, crop rotation and the use of insect-resistant or herbicide-resistant plants) and do so largely without direct financial assistance (Lambert et al 2006; Marsh 1998). However, small farms that rely on off-farm income are less likely to adopt practices requiring extra time or expense than operators of large enterprises who farm for a living.

Higher education, the use of outside expertise, farm household reliance on farm income and receipt of commodity program payments all affect the likelihood of farms adopting practices requiring extra time or expense (such as variable rate application of inputs or integrated pest management). For example, information-intensive technologies such as nitrogen testing fare significantly better with highly educated farmers. Overcoming these educational barriers may require technical assistance, demonstration or consulting services (Caswell et al. 2001). A recent survey (Fertilizer Institute 2008) of 2,000 U.S. farmers managing 2.5 million acres shows:

- Having a conservation plan is a key predictor that farmers will adopt additional BMPS.
- Producers prefer financial assistance over education and technical assistance for the adoption of conservation buffers, GPS yield monitors, irrigation water management, precision agriculture, terraces and water and sediment control basins.
- The most respected information sources are Cooperative Extension, certified crop advisers, agribusiness and NRCS.
- Large-scale farms are more likely to adopt conservation tillage and no-till and are more conservation-oriented than small landowners.
- Economic concerns and time are the primary obstacles to soil testing and about half do not do any testing.

Summary

In summary, when working with groups of farmers to hasten adoption of BMPs, researchers conclude that:

- Most adoption behavior is linked to consideration of relative profitability.
- Attitudes and perceptions are influenced by demographic factors such as age, ethnicity, gender, wealth, experience, education, family size, etc. The producers who are more likely to adopt BMPS have: above average income, greater number of years of formal education; high number of agency contacts; high participation rates in agricultural organizations; greater reliance on mass media; high awareness of conservation problems (e.g. CTIC survey showing that conservation plans were a key predictor); willingness to take risks; are full-time operators; and want to pass their farm/ranch on to children. Larger farms, high gross sales and owner operations are also more likely to adopt BMPs (USDA NRCS 2005).
- Both the actions of leading farmers (= early adopters) and Extension can positively affect the awareness and perceptions of other farmers.
- Peer/community pressure is a potential conflicting objective to be traded off.
- The quality and quantity of farm resources affect perceptions and attitudes, as well as true relative profitability of the innovation to the individual.
- Environmental considerations may fit directly as an element of profit, or may be a conflicting objective to be traded off.
- A farmer's attitude to risk affects perceptions of profitability and riskiness. For example, farmers over-apply nutrients in a rational economic decision process, to address risk of spring field entry, risk of wet conditions precluding side-dress, time utilization of fall field time availability, and variable uptake of nutrient based on year-to-year changes (Sherriff 2005). In these cases, AFT's BMP Challenge may hasten the adoption process by providing a yield guarantee to cover on-farm testing of reduced fertilizer rates.

Other Issues

The Impact of Land Tenure on Adoption

Absentee landowners comprise more than 40 percent of people who own agricultural land in the U.S. and states with the most fertile lands have leasing rates between 53 to 63 percent. Since landowners and tenants are motivated by different objectives, this could impact the use of some BMPs on leased lands (Cox 2011). Year to year renewable leases are the norm although most yearly leases are renewed, on average, for 11.3 years. However, the yearly risk of losing a lease can dissuade the tenant from using some of the longer-term conservation practices on their leased land. Anecdotal information from AFT's listening sessions with producers indicate that year-to-year leases inhibit the adoption of some conservation practices on leased land.

Early research analyses concluded that cash renters (but not share-renters) were less likely than owner operators to use conservation tillage. Both cash-renters and share-renters were less likely than owner operators to adopt practices that greatly reduced nutrient and soil sediment runoff over the longer term (like grassed waterways, strip cropping and contour farming) (Soule et al 1999; Soule et al. 2000; Magleby 2003;).

More recent USDA ERS surveys confirm that fewer conservation practices are generally used on rented land (Nickerson and Borchers, 2011). For example, in wheat, 45 percent of owned acres receive cost share to install terraces versus only 23 percent of rented acres, 81 percent of owned acres receive cost share for filter strips versus 37 percent for rented acres and 73 percent of owned acres receive cost share for riparian buffers versus 13 percent for rented acres. Fifty percent of corn acres are rented and while surveys find no difference in the use of conservation buffers on leased or owned land, significantly fewer stormwater runoff controls and soil erosion controls are used on leased land. With soybeans, 60 percent of the crop is grown on leased land and surveys find significantly fewer conservation buffers, stormwater runoff controls and soil erosion controls are used on the leased land.

Currently, producers are competing for limited farmland acres to lease. This means that landowners could require their tenants to use conservation practices and an untapped segment of absentee landowners might be willing to do just that. A survey of about 2,000 absentee landowners finds that conservation is very important to them and could influence their decisions about land use (Agren 2007; Agren et al. 2010). Most have above average levels of education and income and average 60 years in age. They tend to value conservation, wildlife, aesthetics and recreation more than income and tradition. However, most depend heavily on their tenants or renters to make managerial decisions and nearly 75 percent have never enrolled their farms in a state or federal conservation program. Many were unaware of various conservation agencies as a source of information although more than 70 percent had ready access to the Internet and most had high-speed Internet service. Agren and its partners have now incorporated this information into innovative outreach campaigns to market conservation to absentee landowners. In 2011, Drake University Agricultural Law Center and the Leopold center released a guide to sustainable farm leases and established a website for absentee landowners. Depending on the number of leased acres in a watershed, reaching out to enlist absentee landowners could be an effective approach to getting more conservation practices on the ground.

The importance of language

The AFT listening sessions with conservation professionals and producers have reinforced the important of the language used in messaging. For example, f producers in the Sandusky River watershed, the term "conservation" implies taking land out of production or using no-till. The conservation professionals we talked with recommending using the term 'resource management' rather than 'conservation practices'. The presumption is that "conservation" implies that 'they don't want me to do anything with the ground,' is associated with the term 'environmental' and also implies 'government.' At the same time, communicating effectively to build public support for conservation within a watershed also requires strategic use of language, avoiding terms like "landscape" and "ecosystem services"(Metz and Wiegel 2009).

Getting producers to participate in water quality projects
From 1981 to 1995, USDA's Rural Clean Water Program (RCWP) invested in projects with the goal of enlisting 75 percent of producers in targeted watersheds. Afterwards, they surveyed 21 of the RCWP projects to determine how to recruit and retain participants in voluntary NPS pollution control projects. Their results are still highly relevant (Osmond and Gale, 1995; USDA Water Quality Program 1997))

Producers who are more aware of water pollution (and receive most of their water quality and conservation information from government agencies and farm magazines) participate in greater numbers than farmers who are less well informed. Producers are also most likely to participate when they understand that their own agricultural practices affect the water quality of a local water resource. For the most part, producers who did not participate in the RCWP projects did not believe that water pollution was a problem. Conversely, twice as many RCWP participants as non-participants state that they believe water quality is a problem. Producer participation also depends on farmers valuing the impaired water resource. For example, because Iowa RCWP project participants valued a recreational lake that was threatened by sediments eroding from the surrounding cropland, they were willing to adopt new agricultural practices. In addition, if farmers perceive a need to alter production practices for reasons other than enhanced profit, they are willing to adopt practices that increase their risk or decrease their profits as long as it benefits the local environment and their farms remain financially viable.

Other recommendations from successful water quality projects include: for long term success of the program, emphasize practices that generate higher returns like conservation tillage, nutrient management, irrigation water management and integrated pest management; offer flexible financial assistance (with varying incentives levels and a collection of practices eligible for assistance); offer education, technical and financial assistance in a coordinated fashion; provide field testing and demonstrations of new practices which do not have a local history of use; involve local stakeholders early in project planning; pay attention to water quality monitoring and project evaluation and establish an effective mechanism for tracking changes in crop management in the project area (including management changes on fields not receiving assistance); and make sure the project allows adequate time to set results (the Water Quality Program projects were set up as five year projects).

Marketing a BMP program
Virginia's Department of Conservation and Recreation recently re-examined its approach to marketing water quality BMPs using focus groups, telephone surveys and phone interviews with

other states (Virginia Conservation Marketing Warehouse). Farmers identify with conservation and stewardship, are tired of being overlooked and even blamed for water pollution, may not be aware of cost-share programs and don't understand how some BMPs work. The most effective message is that conservation methods can be compatible with production and a uniform brand or logo that conveys the essence of a campaign can be effective since visual repetition builds awareness. In this case, the most effective message for Virginia was "you have to produce, you want to conserve … learn how you can do both at your local SWCD." They placed adds in rural newspapers, on rural radio stations and on outdoor billboards. They also found that research helped gain buy-in and is the best basis for effective communication. Producers also responded to face-to-face communications with trusted sources, field signs and partnership events with their producer associations.

Gap Analysis of Adoption in the Upper Salt Fork

Snapshot of the Watershed

The Upper Salt Fork watershed in Illinois is a priority area for the Mississippi River Basin Healthy Watersheds Initiative (MRBI) due to extensive subsurface tiling that provides a pathway to the Salt Fork for dissolved nutrients and agrichemicals. The watershed has an established total maximum daily load (TMDL), a comprehensive watershed plan and a highly engaged watershed implementation committee. The University of Illinois has been establishing monitoring sites at the edge of fields within sub-surface tile systems and already has two years of in-stream monitoring data on which to build.

The collaborators are working in the Spoon Branch segment of the Upper Salt Fork in Champaign County, Illinois. It covers 43 square miles (27,478 acres) (about 5 percent of the county) and is dominated by corn (49 percent of the area) and soybeans (42 percent of the area). The Spoon River has been designated as "biologically significant" with 15 species of fish; 21 species of mammals, 46 species of trees and over 200 species of birds. The average farm size in Champaign County is 396 acres. Roughly 120 active producers farm in this watershed and 50 percent of the cropped acres are leased.

The project proposed to work with at least 25 farmers on 7,500 acres to address water quality issues. Targeted BMPs include reduced tillage for corn and soybeans; nutrient management (following university recommendations) and advanced nutrient management (planned N reduction, split N, PSNT, Illinois Soil N Test, variable rate applications); tile drainage management; filter and buffer strips; nitrification inhibitors; slow release nitrogen fertilizers (ESN); wetland restoration; and improved manure management capabilities including application equipment, manure storage, and improved utilization efficiency. The project is relying mostly on federal cost share funds set aside in the Environmental Quality Incentives Program (through a Cooperative Conservation Program Initiative grant) to help farmers in this watershed implement these practices. The project is also using AFT's BMP Challenge to help persuade farmers who hesitate to adopt BMPs because they may impact yields. The project is monitoring the resulting impacts of the implemented BMPs on water quality and collecting information to show the impacts of BMP adoption on crop yields and farm profitability with an eye towards scaling up in the future.

Original Plan
Based on our review of the BMP adoption literature, our listening sessions with producers around the Midwest and our conversations with collaborators in the Upper Salt Fork, we proposed the following plan: 1) Engage farmers through our active relationships with independent crop advisers, agricultural cooperatives, state and county agencies and watershed groups; 2) Enlist crop consultants, extension and conservation district staff to recruit farmers, oversee on-site work, and/or act as third-party verifiers (outreach to conservation districts, crop consultants, extension agencies, agricultural organizations and other key influencers); and 3) Provide farmers with yield/income guarantees so they will change their practices.

In addition, we proposed to enlist two to three Illinois farmers currently using and benefiting from implementing a more effective suite of nutrient management practices to serve as spokespersons and "roving expert farmers." Armed with media training, we proposed to use these "roving expert farmers" to represent the project at the Farm Progress Show, Illinois Commodity Conference and the Farm Broadcasters Trade Talk.

> Progress to date:
> The Soil and Water Conservation District reports that 13 producers (out of a pool of about 110) now have EQIP contracts through the CCPI program (averaging two contracts per producer). Total acreage signed up to date for conservation practices is 6,108 acres out of a potential 27,500 acres. At least five additional farmers have implemented eligible practices independently of EQIP funding. The AFT webinar on the BMPC successfully recruited one certified crop advisor in the watershed and he has signed up two producers so far. It is important to note that the BMPC has been a hard sell in all of the states this year. This may reflect the high price of corn and unwillingness to try anything new and put any potential profits at risk.

New Information
Barriers and solutions to BMP adoption in the Midwest:
Since submitting our proposal, AFT has completed five more listening sessions with producers in the Midwest to identify conservation challenges, barriers and solutions to adoption. The consensus of the listening sessions was that the most important considerations in determining which BMPs producers routinely use are 1) economics and 2) its potential impacts on crop yields. Practices that producers might implement more widely if some of their costs are covered include Global Positioning Systems (GPS) and Geographic Information Systems (GIS) to precisely guide both tillage and fertilizer application equipment (e.g., Real Time Kinematic (R-T-K) signal precision technology can cost from $10,000 to $15,000 to subscribe to on an annual basis); use of grid sampling to more precisely target applications; use of slow-release N fertilizers; use of bioreactors for tile outlets; use of specialized equipment to spread manure; use of a no-tillage corn planter; the installation of two-tier stream bank/ditches (these are expensive and take land out of production but are relatively easy to maintain); and use of hybrid seeds (e.g., helping cover the rapidly escalating costs of corn varieties that use nitrogen more efficiently or produce their own source of N).

Other practices with shortcomings that investments might overcome include partially covering lost profits from planting lower yielding, shorter season crops to accommodate the use of cover crops to reduce run-off; incentives to keep land currently out of production in the Conservation Reserve Program (CRP) from coming back into production by allowing producers to deviate from USDA Natural Resources Conservation Service (NRCS) 10 year re-seeding requirements; crediting the use of hay-in buffers (strips that could be routinely cut for hay with both the credit payments and hay sales supporting the practice and the need for routine maintenance and reseeding); incentivizing the use of grass waterways by allowing producers to extend the seeding date beyond September (as required by NRCS); and providing additional funds for streamside fencing and riparian buffers—practices that are currently oversubscribed in NRCS cost-share programs.

Practices that show promise but may require more technical assistance or information for producers to implement include managed tile-drainage and the use of hybrid cover crops.

Results of surveys of producers in the Salt River Watershed:
In the spring and summer of 2010, our collaborators at the University of Illinois interviewed 40 farm operators and landowners (including four drainage commissioners) as part of their project in the Salt River watershed to address nitrate losses by modifying drainage tile lines. They also mailed a survey to 306 farm operators in July 2010 (the names were obtained from the Farm Security Agency through the Soil and Water Conservation Districts) and received 82 back for a 31 percent response rate (considered normal) (David et al 2011).

This data is currently being analyzed but the preliminary results provide useful information about the possible motivations of producers in the Upper Salt Fork. Based on a presentation of early results delivered in January, survey responses indicate that most producers in the Upper Salt Fork think water quality conditions are good. Forty four percent thought it was very good and 16 percent thought it was excellent. However, it appears that producers associated the question about water quality with drinking water, not with the Salt Fork River. When asked about their level of concern about water quality, most were concerned primarily with drainage rather than the quality of runoff. They are more concerned with water standing in the fields when they get heavy rains. Indeed, 82 percent of the respondents indicated that their fields need more drainage. Neither size of farm nor farm income made any difference to their perceptions of conditions or concern about water quality. When asked to identify sources of water quality problems, the top four sources were sediment, municipal discharges, nitrogen and phosphorus but many didn't know. Even the top sources of water quality problems were not considered serious problems. Only 17.3 percent thought nitrogen was a severe problem and 13.5 percent thought phosphorus was a severe problem.

When queried about what factored into their water quality management decisions, over 90 percent said: improving or maintaining the appearance and integrity of my farm, improving or maintaining the conditions of my farm for future generations of farmers in my family or improving or maintaining my relationships with neighboring farmers. In contrast, 83 percent said improving my farm production and bottom line, 78.2 percent, improving the quality of water downstream and 78 percent promoting conservation of natural resources.
The most commonly used practice in the watershed is reduced tillage (used by 87 percent of the respondents) followed by no till or strip till (60 percent), grassed waterways (60 percent), nutrient management (58 percent), filter strips (48 percent) and precision application

technologies (43 percent). Respondents used more permanent structures such as field terraces (18 percent), grade stabilization structures (16 percent) and saturated lateral riparian buffers (tiles parallel to ditches) (14 percent) infrequently. Only 9 percent used an annual cover crop, 8 percent had installed or restored wetlands, 8 percent were using controlled drainage (managing water table levels), 7 percent were injected phosphorus, 4 percent had installed ponds and 4 percent were using bioreactors to intercept tile drainage at the edge of fields.

When asked what might convince them to modify their farm operations to improve water quality, most farmers indicated they would be willing to change if:

- Convincing evidence showed modifications would increase farm profitability.
- Financial incentives were provided to cooperating farmers.
- If the farmers around them adopted the practices.

Fewer farmers answered:

- If the Soil and Water Conservation District recommended the practices.
- If federal or state regulations required them to improve the water quality of agricultural runoff.

Very few farmers would be willing to change practices based on:

- Convincing evidence from local demonstration plots,
- Scientific evidence showing the effectiveness of BMPs in reducing nutrient loss and
- Endorsements of the BMPs by University of Illinois Extension or by the county Farm Bureau.

When questioned about the barriers to implementing water quality practices on their farms, the issues that mattered the most were:

- Personal out-of-pocket expense and the lack of government funds for cost-share.
- Possible interference with their ability to change land use practices as conditions warrant.
- Concerns about reduced yields.
- Not having access to equipment that they might need.

Other identified constraints were the possibility of environmental damage caused by the practice, requirements or restrictions of government programs, the lack of available information about a practice and not being able to see a demonstration of the practice before they decide. A few farmers indicated that they did not own the property, that the approval of their neighbors was important, that no one else was implementing the practice or that they did not want to participate in government programs.

The most important information sources were field demonstrations and farm magazines and newsletters.

Proposed project modifications *(recommendations in italics)*

1) Engage farmers through our active relationships with independent crop advisers, agricultural cooperatives, state and county agencies and watershed groups;

- *Most of these farmers suggest water quality in the watershed is not a problem. Therefore, conventional methods for creating awareness opportunities for education may not be as effective. The most persuasive messages seem to be improving or maintaining the appearance and integrity of their farms, improving or maintaining the conditions of their farms for future generations of farmers in my family or improving or maintaining their relationships with neighboring farmers. These may be important messages for our sell sheets. However, the results of the RCWP projects show that producers are more likely to adopt water quality BMPs if they recognize that water quality is a problem, they accept that their operations contribute to this problem and it impacts a local water body that they value. We still need to tell that story.*
- *To help convince farmers that their operations are "leaking" nutrients, we should continue to explore and expand the role of edge-of-field or place-based monitoring in this watershed. The work done in Virginia by the SWCDs to determine the best way to promote BMPs found that research helped gain buy-in and is the best basis for effective communication.*
- *Based on the information we gleaned from the Sandusky River watershed in Ohio, we should consider using the term "resource management" and avoid using the term "conservation."*
- *Once we have their attention, the sell sheets need to tell them that the BMP can increase farm profitability and that we can provide financial incentives to cooperating farmers (EQIP, BMPC) (e.g. the Virginia "you have to produce, you want to conserve" message).*
- *As more and more farmers adopt the BMPs, we can expect the process to speed up since many of these farmers are holding back, waiting to see if their neighboring farmers adopt the BMPs.*
- *The most important information sources are field demonstrations and farm magazines and newsletters. We could also consider using outdoor billboards and maybe providing signage on participating farms with a easily identifiable logo.*
- *Although the watershed survey did not ask about the importance of local radio programs, the national surveys done by farm broadcasters indicate farm radio shows remain one of the best ways to reach producers.*
- *In radio spots, we can interview early adopters and have them deliver the "persuasive messages" outlined above along with the positive impacts on their farm's profitability. We can then mention the availability of cost share dollars and how to sign up.*
- *Educating and enlisting agricultural retailers should continue to be a top priority since they may be the best way to reach farmers who are engaging in inappropriate behaviors. In addition, we want local vendors to offer the appropriate application equipment and reinforce our message.*

2) Enlist crop consultants, extension and conservation district staff to recruit farmers, oversee on-site work, and/or act as third-party verifiers (outreach to conservation districts, crop consultants, extension agencies, agricultural organizations and other key influencers);

- *The Soil and Water District is still a key influencer but extension and the county farm bureau appear to be lower on the list.*
- *Survey results indicate that scientific data on BMPs and convincing results from local demonstration plots do not seem to strike a chord with these farmers. At the same time, they indicate that field demonstrations are an important source of information for them and at least some of these farmers need to see evidence that a BMP works before they adopt it. It makes sense to continue demonstrations and education efforts, like the recent workshop in*

Royal that brought together area producers and leading agronomists, researchers, and agency staff this spring.

- *Only a few farmers indicate that they may not use a practice on land that they lease. However, 50 percent of the cropland in this sub-watershed is leased so getting the word out about this project and its importance to the public could reach absentee landowners living in the watershed and maybe persuade them to follow up with their tenants*
- *Securing more visible support and buy-in from commodity groups and farm organizations for this project would heighten its importance. This, in turn, may persuade more farmers to participate. If Illinois agriculture can come together in a MRBI watershed where producers are implementing conservation practices that are monitored for their environmental and economic impacts, it can provide important evidence about whether producers can maintain productivity while significantly reducing nutrient runoff. One option is a highly promoted bus tour to show these groups what the project has and hopes to accomplish and persuade these groups to back the monitoring effort.*

3) Provide farmers with yield/income guarantees so they will change their practices.

- *Limitations and barriers noted by farmers in the watershed were out of pocket expenses, lack of cost share, loss of flexibility, reduced yields, and lack of specialized equipment. The increased availability of EQIP funding through the CCPI can help address concerns about out of pocket expenses, lack of cost share and lack of equipment. The BMP Challenge can help address the concerns about yield loss by covering on-farm trials. The option of testing BMPs on the farm risk-free before widely adopting them should also help farmers decide whether loss of flexibility is truly an issue.*
- *We will need to provide convincing evidence to these farmers that BMPs can improve farm profitability.*
- *We mailed out a national survey to 150 current and past BMPC recipients early in April. The results should give us a better picture of likely clients and help us refine our recruiting messages.*

In addition, we proposed to enlist farmers currently using and benefiting from implementing a more effective suite of nutrient management practices to serve as spokespersons and “roving expert farmers” to represent the project at the Farm Progress Show, Illinois Commodity Conference and the Farm Broadcasters Trade Talk.

- *Spokespeople should be early adopters, not innovators i.e. farmers who have waited a bit and really analyzed all available data before using a practice.*
- *We should also chose early adopters for our case studies of producers who have adopted prioritized BMPs in the project area because their stories will be more compelling to their fellow farmers.*
- *We could generate publicity and provide public acknowledgement of improvements and successes by hosting an annual award/certification program to recognize stewardship in the watershed. This might encourage more producers to pursue changes on their operations as well. In addition, we could recognize SWCD staff, CCAs and others who have played a critical role in getting the word out. We could hand out awards at an annual dinner for local Soil and Water Districts.*
- *We may be able to use community support structures such as environmental education programs and centers to make the public more aware of what farmers in their watershed are*

doing to protect water quality and reach out to absentee landowners who live in the watershed. This would entail putting together a presentation (either power points or a short video) that can be used at meetings of the Sierra Club, Audubon, the League of Women Voters, Illinois Stewardship Alliance and other active groups in the watershed.

4. Continue to expand the number of monitoring sites with the watershed and develop a communication plan to disseminate and incorporate monitoring results in outreach to producers and others in the watershed.

- *Currently, AFT is working with several partners in the Sandusky River watershed in Ohio which drains into Lake Erie. Dissolved phosphorus from farm fields is causing significant algal blooms in the lake. Although farmers in listening sessions were initially skeptical about whether they were causing this problem Heidelberg College has been monitoring water quality in the watershed with both in-stream monitors and some edge of field monitors. Combined with information from computer models and historic data, Heidelberg has been able to convince both producers and agricultural retailers that there is, indeed a problem. Producers view Heidelberg as a credible source of information and having the same message repeated by conservation professionals and agricultural retailers in the Sandusky is starting to make a difference. We should try to generate the same level of acceptance, concern and momentum in the Upper Salt Fork.*
- *It will also be important to establish an effective mechanism for tracking changes in crop management in the project area (including management changes on fields not receiving assistance). This can help us correlate future improvements in water quality with changes on the ground. We recommend continuing to look for funding to develop software that can enable projects at a watershed level to track all conservation practices in a watershed and share the results to motivate producers and developing a template to collect data in the meantime.*

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Appendix D. Research Publications on Monitoring Results in the USF

Published February 20, 2015

Journal of Environmental Quality SPECIAL SECTION

IMPROVING NITROGEN USE EFFICIENCY IN CROP AND LIVESTOCK PRODUCTION SYSTEMS

Navigating the Socio-Bio-Geo-Chemistry and Engineering of Nitrogen Management in Two Illinois Tile-Drained Watersheds

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Abstract

Reducing nitrate loads from corn and soybean, tile-drained, agricultural production systems in the Upper Mississippi River basin is a major challenge that has not been met. We evaluated a range of possible management practices from biophysical and social science perspectives that could reduce nitrate losses from tile-drained fields in the Upper Salt Fork and Embarras River watersheds of east-central Illinois. Long-term water quality monitoring on these watersheds showed that nitrate losses averaged 30.6 and 23.0 kg nitrate N ha^{-1} yr^{-1} (Embarras and Upper Salt Fork watersheds, respectively), with maximum nitrate concentrations between 14 and 18 mg N L^{-1}. With a series of on-farm studies, we conducted tile monitoring to evaluate several possible nitrate reduction conservation practices. Fertilizer timing and cover crops reduced nitrate losses (30% reduction in a year with large nitrate losses), whereas drainage water management on one tile system demonstrated the problems with possible retrofit designs (water flowed laterally from the drainage water management tile to the free drainage system nearby). Tile woodchip bioreactors had good nitrate removal in 2012 (80% nitrate reduction), and wetlands had previously been shown to remove nitrate (45% reductions) in the Embarras watershed. Interviews and surveys indicated strong environmental concern and stewardship ethics among landowners and farmers, but the many financial and operational constraints that they operate under limited their willingness to adopt conservation practices that targeted nitrate reduction. Under the policy and production systems currently in place, large-scale reductions in nitrate losses from watersheds such as these in east-central Illinois will be difficult.

Managing agricultural nutrients in the interest of water quality is a critical global concern and is recognized as one of the grand challenges for engineering in the 21st Century (Schipper et al., 2010). The environmental impacts of hypoxia in the Gulf of Mexico have raised alarms about nutrients flowing through the Mississippi River Basin (Rabalais et al., 2002). Extensive hydrologic modifications, including channelization and subsurface tile drainage, are common in watersheds dominated by intensive corn–soybean production in the midwestern United States (Baker et al., 2008). This is a "leaky" system, particularly for nitrate N, and large nutrient loads are carried downstream even when farmers follow best management practice recommendations (Royer et al., 2006; Baker et al., 2008; Hatfield et al., 2009; David et al., 2010). Policies and plans to address the loss of nutrients from agricultural watersheds have been relatively ineffective. A 2008 plan (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008) called for 45% reductions in total N and total P loads in the Mississippi River, beyond the 30% reduction in total N called for in 2001, yet there is no evidence of any decrease in nutrient loading to date (Sprague et al., 2011; David et al., 2013).

Many approaches to addressing the agricultural nutrient loading problem have been proposed, including riparian buffers, cover crops, altering timing and mode of fertilization, water table management, and off-field practices to increase denitrification (USEPA, 2007; Schipper et al., 2010; Skaggs et al., 2012). Previous research has found riparian buffers to be ineffective in locations where agricultural fields are drained via tiles directly into streams and ditches (Kovacic et al., 2000; Lemke et al., 2012). Thus, additional engineered solutions at the end of tiles are recommended, such as constructed wetlands and bioreactors (Kovacic et al., 2000; Woli et al., 2010; Christianson et al., 2012). Seasonality of fertilizer applications and runoff

J. Environ. Qual.
doi:10.2134/jeq2014.01.0036
Supplemental data file is available online for this article.
Freely available online through the author-supported open-access option.
Received 27 Jan. 2014.
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Abbreviations: CCSWCD, Champaign County Soil and Water Conservation District; C–C, corn–corn rotation; C–S, corn–soybean rotation; DWM, drainage water management; FD, free drainage; NT, North Tile; ST, South Tile.

rarely correlate with the timing of poor water quality, creating a complex management situation (Royer et al., 2006). Despite their effectiveness, biogeochemists and engineers acknowledge that incentives may not be high enough to install engineered systems or to alter crop diversity (David et al., 2013).

In a 2011 memo (USEPA, 2011), the USEPA highlighted the importance of collaborative actions to reduce nutrient loading and develop watershed-scale plans and stewardship incentives to accelerate implementation of effective agricultural practices. Bridging from biophysical science and engineering to decision-making regarding water quality requires understanding what farmers are able and willing to adopt. Not all conservation practices are appropriate in every situation, and, even if adopted, they may not necessarily correlate with conservation intentions or other conservation behaviors (Nowak and Korsching, 1998). Whereas scientists and engineers may consider nutrient management a set of known truths regarding risks to water quality and ecosystems, farmers may have different experiences, knowledge, and perspectives influencing their willingness and ability to alter their practices (Raedeke and Rikoon, 1997).

Literature reviews have documented factors influencing farmers' adoption of water quality conservation practices (Christensen and Norris, 1983; Prokopy et al., 2008). Farm size and income, ownership versus renting, social networks, and various environmental or risk-related attitudes are among the few factors found to be influential, although often in different directions across studies. The lack of consistent findings across projects, time, or geographic study areas indicates that context likely matters when trying to understand farmers' motivations. Additionally, recent literature on agricultural conservation has focused largely on participation in conservation programs and combines inquiry on soil erosion with nutrient runoff and water quality (Arbuckle, 2013; Reimer and Prokopy, 2013), making it difficult to parse perspectives on water quality and nutrients from other more traditional farm conservation issues. Rural Iowa farmers and residents saw the benefits of conservation for water quality but rarely prioritized them or saw them as compatible with farming objectives or constraints (Atwell et al., 2009a, 2009b). Studies consistently highlight factors beyond finances as influencing farm practices, including family and social issues, skill and knowledge, attitudinal intensions, and interconnections and complexity in the farm context to design appropriate policies (Battershill and Gilg, 1997; Maloney and Paolisso, 2006). Scaling up or connecting local issues with meso- and macro-level factors and change drivers is advocated to situate individual farm producers in broader economic and political contexts for more effective policies and vulnerability mitigation than offered by individual producer-oriented programs and regulations (Stuart and Gillon, 2013). Our work builds on these ideas by assessing the empirical conditions related to individual farmers, farms, and small watersheds and connecting these findings to the broader context of policy and strategy at larger scales.

Building interdisciplinary research teams to combine sciences and methods generates the new knowledge needed to address complex issues (Kotchen and Young, 2007; Hufnagl-Eichiner et al., 2011; Jahn et al., 2012; Repko, 2012). Our team assessed social, biophysical, and engineering dimensions of nutrient management in two Illinois watersheds. Our overall objective was to investigate an array of practices and technological advancements through in-field installation and experimentation, including impacts on nutrient loading and farmer perspectives on nitrate losses and conservation practices. The guiding research questions for this work included: (i) What are the water quality conditions in intensive agricultural and headwater watersheds of east-central Illinois? (ii) What are the water quality perspectives of farmers, and how do they compare with field measurements? (iii) How do various in-field and end-of-tile water quality conservation techniques affect nitrate losses? (iv) Are farmers familiar with these nitrate conservation techniques, and are they willing to adopt them? What factors influence willingness to adopt new water management practices? and (v) What are the broader factors affecting farm and conservation decision-making and managing nutrients in the agricultural water system?

Materials and Methods

Study Area

The study involved two watersheds in east-central Illinois as designated by river monitoring stations managed by the USGS. The Embarras River watershed at the USGS site no. 03343400 is 481 km^2, and the Salt Fork of the Vermillion River watershed at USGS site no. 03336900 is 347 km^2. We have sampled these locations since January 1993 (Embarras) and April 2008 (Upper Salt Fork), and there are previously published studies on aspects of the Embarras River Watershed (e.g., David et al., 1997; Royer et al., 2006; Gentry et al., 2007). These watersheds consist of relatively flat landscapes (<2% slopes) with soils that are poorly or very poorly drained Mollisols, with Drummer being the dominant soil series (fine-silty, mixed, superactive, Mesic Endoaquolls). The dominant topographic features in this area of Illinois are glacial moraines, which often create watershed boundaries and provide recharge to streams. Before agricultural conversion, this area was a wet tall grass prairie. In the late 1800s, drainage districts were established, headwater streams were dredged and channelized, and tile drainage was extensively installed (David et al., 2001). These modifications greatly altered the hydrologic cycle by draining wetlands and creating fertile, arable soils. Enhanced drainage increased crop production, and today artificial drainage is often installed in grid patterns where entire fields are now drained. Land use in these watersheds is dominantly row crop agriculture (>80%) under a corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] rotation. For more information see David et al. (1997).

Typical agriculture in these watersheds includes conservation tillage, extensive fall application of N fertilizers, and cultivation of corn and soybeans on >90% of the land area. There is almost no animal agriculture. The Upper Salt Fork Watershed has an active watershed group that formed first as a steering committee in 1990 of the Champaign County Soil and Water Conservation District (CCSWCD) and later as a watershed group involving diverse stakeholders, including the agricultural industry, Champaign-Urbana Sanitary District, environmental groups, university scientists, and local governmental representatives. Efforts to improve water quality have occurred through this group and through programs of the American Farmland Trust, who led the selection of the Upper Salt Fork Watershed as one of the USDA Natural Resources Conservation Service Mississippi River Basin Initiative watersheds in Illinois. Farmer characteristics from the study area, including participants, counties, and the state of Illinois, are included in the results section below in comparison to our survey respondents.

Biogeochemical and Engineering Data Collection and Analysis

Our research group is involved in many on-farm research trials in these two watersheds to evaluate various nutrient remediation practices under real-world conditions and constraints. We are evaluating end-of-tile techniques and in-field solutions for reducing the flow of nutrients (especially nitrate) from agricultural fields to surface waters.

River Sampling

Water grab samples were typically collected weekly at the gaging stations in the Embarras and Upper Salt Fork watersheds; we also attempted to sample all high flow periods on a daily basis. River samples were filtered (0.45 μm pore size) and analyzed for nitrate by ion chromatography (Dionex). Linear interpolation was used to estimate a nitrate N concentration for every daily discharge value to determine daily and annual loads, and earlier studies have published some of these data for the Embarras River (David et al., 1997; Royer et al., 2004, 2006). Annual riverine data are expressed on a water-year basis (1 Oct. of the previous year through 30 Sept. of the named year). Trends in nitrate concentration in the Embarras River were assessed using the Seasonal Kendall test from the USGS that performs the Mann-Kendall trend test for individual seasons of the year, which we defined as four seasons (Helsel et al., 2006). Possible trends in nitrate yields from the Embarras River watershed were assessed using linear regression in SAS v. 9.3, with year and cm of runoff as independent variables.

Drainage Water Management

The drainage water management study was conducted on a 34-ha field located in the Spoon River subwatershed of the larger Upper Salt Fork watershed. A corn and soybean rotation has been cultivated under continuous no-till farming for the past 27 yr. During 2011 soybean was grown; corn was grown in 2012. A side-dress fertilizer solution had been applied in the form of urea-ammonium nitrate (28%) at a rate of 180 kg N ha^{-1} during the spring of 2012. The 34-ha field was divided into two independent subsurface tile drainage systems: South Tile (ST) and the North Tile (NT), with areas of 10.9 and 23.1 ha, respectively. The field has a parallel subsurface tile drainage design with lateral tiles 15.2 cm in diameter that were installed approximately at a 1-m depth and 15 m apart. Each of the lateral tiles was connected to a tile main 20.3 cm in diameter that drained to an Agri Drain structure that was used to monitor the outflow and water table level from each field. The adjustable flashboards were used to increase and decrease the outlet depth of the drainage systems. To estimate the flow discharge from each field, a 60° V-notch board was installed and used as a reference point to measure the water table level in both Agri Drain structures. Both structures were equipped with pressure transducers and data loggers to continuously record the water level behind the v-notch. Water samples were collected weekly to biweekly during base flow conditions. Samples were collected at least daily during high discharge periods after precipitation events; a few high flow events were sampled several times a day. All samples were analyzed for nitrate as described above.

A nearby tile system (tile A described below) draining a corn/soybean field was used to estimate the flow from ST and NT during the drainage water management (DWM) periods (including 1 wk after the outlet was opened). Daily flow from this 6.9-ha field was regressed against daily flow from NT and ST outside of the DWM period in 2012 and 2013. It had the best relationship of daily flow with NT and ST tiles of five additional tiles that were monitored in the Upper Salt Fork Watershed. Regression equations explained about 80% of the daily flow between tile A and NT and ST, with separate equations developed for each.

Constructed Wetlands and Woodchip Bioreactors

In 1994, three wetlands were constructed in the floodplain of the Embarras River at the end of tile systems draining corn and soybean fields. Wetland sizes were based on a 20:1 drainage area and ranged from 0.3 to 0.8 ha. Input/output balances for N were determined (Kovacic et al., 2000). Currently we are studying these same wetlands to reassess their effectiveness of removing nitrate from tile drainage water nearly 20 yr after creation and establishment. The results are not presented here, but it is important to note that the Embarras Watershed has these wetlands in the context of the surveys conducted.

On the same farm, a woodchip bioreactor was constructed in March of 2012 on a pattern-drained, 20-ha field in a corn and soybean rotation. Located at the end of the 30-cm main tile outlet, the bioreactor area was 6 by 15 m by 1.3 m deep. A four-chamber Agri Drain structure fitted with three flashboard risers and V-notch boards, four pressure transducers, and two dataloggers was used to divert tile water into the woodchips and to receive the return flow from the bioreactor. Based on design parameters, the bioreactor was sized to remove approximately 50% of the tile nitrate load because high flow events can produce substantial bypass flow (tile water that flows over the middle V-notch board and does not pass through the woodchips and does not get treated). Weekly grab samples were supplemented with ISCO automatic water samplers to determine nitrate concentrations in and out of the bioreactor. This study evaluated bioreactor performance by quantifying input/output balances.

Fertilizer Timing

On another farm in the Upper Salt Fork, tile drainage from two adjacent fields under two different cropping systems was monitored: (i) a split application of fall and spring fertilizer N in continuous corn (C–C) and (ii) a split application of spring and side-dress fertilizer N in a corn–soybean rotation (C–S) where corn was planted in 2010 and 2012. In C–C, fall fertilizer N was applied as anhydrous ammonia with a nitrification inhibitor in late November, whereas spring fertilizer N was a 28% solution with herbicide. In C–S, spring fertilizer N was applied as a 28% solution with herbicide and side-dress was also a 28% solution. In C–C, the total fertilizer N applied in 2011 was 224 kg ha^{-1} with 135 kg ha^{-1} in the fall, and the total fertilizer N applied in 2012 was 246 kg ha^{-1} with 179 kg ha^{-1} in the fall. In C–S, total fertilizer N applied was 213 kg ha^{-1}, with 179 kg ha^{-1} applied as a side-dress. The tile in C–C drained 20 ha and the tile in C–S drained 7 ha. At the end of each tile system an Agri Drain structure with a V-notch board, pressure transducer and datalogger was installed. Water samples were collected weekly and supplemented with ISCO automatic water samplers during high flow events. Nitrate was analyzed as previously reported.

Cover Crops

After the severe drought of 2012, a cover crop was planted on another tile-drained field adjacent to the C–S field mentioned above to act as a N "catch" crop to absorb unused fertilizer after a year of limited corn growth and N accumulation. The C–S field without the cover crop was Tile A (7 ha), and the adjacent tile within the same C–S production system that received the cover crop was Tile B (17 ha). Again, an Agri Drain structure with a V-notch board was installed at the end of each tile system, along with a pressure transducer and datalogger. Water samples were collected weekly and supplemented with ISCO automatic water samplers during high flow events. Nitrate was analyzed as previously reported. A mixture of annual ryegrass and tillage radish was aerially seeded into standing corn on 8 September. Using 0.25-m^2 quadrats, aboveground biomass of the cover crop was measured on 8 November. Before initiating the cover crop experiment, there were two previous years of data from these two tile systems. Although the tile nitrate yield of Tile A was somewhat greater than Tile B, we used the previous 2 yr of data to account for this inherent difference between the two tile systems.

Social Science Data Collection and Analysis

Several social science research methods were implemented to reach farmers in different ways, including presentations at various CCSWCD events and interviews in addition to surveys, given the typical reluctance of farmers to respond to traditional surveys (Pennings et al., 2002). The results below draw predominantly on survey data collected in the two watersheds. Interview data and associated q-sort ranking activity results form the basis for addressing the last research question about farming complexity.

Farm Operator Survey Methods

Embarras farm operators were surveyed in summer 2012, and those from the Upper Salt Fork watershed were surveyed in spring 2013. All farm operators in each watershed (EMB 336, USF 284) were eligible for participation and were identified by combining CCSWCD geo-referenced farm data with Farm Service Agency contact information for farmers. Surveys were administered using the Modified Tailored Design Method (Dillman et al., 2009), including an initial mailing of survey and cover letter, a reminder/thank you postcard 2 weeks later, and a second survey wave shortly thereafter. A $2 bill incentive was included in the Embarras survey, and a $5 gift card to a local farm supply store was included as an incentive in the Upper Salt Fork survey (for consistency with a previous survey).

Survey questions focused on current farm characteristics and practices, perceptions of water quality, factors influencing water quality management decisions, willingness to adopt specific practices, and personal characteristics. A number of questions were taken or modified from the Social Indicators for Planning and Evaluation System program (Genskow and Prokopy, 2011), and others came from interviews and project leader experience. Questions regarding factors influencing water quality management decisions included the level of interest in new agricultural practices related to production and conservation as well as three batteries of questions, including (i) importance of issues when making water quality management decisions on farm, (ii) how much issues limit one's ability to implement water quality conservation practices on farm, (iii) willingness to modify farm operation to improve water quality under various circumstances, and (iv) personal characteristics, including age (year born), gender, level of education, and gross farm income.

Survey data from the two watersheds were aggregated and statistically analyzed using SPSS, Version 21. Our quantitative analysis focused on descriptive statistics for key variables and on various appropriate bivariate analyses (independent t test or chi-square, depending on the nature of the variables) to assess differences across watersheds and the influence of farm size and ownership characteristics.

Farm Operator and Landowner Interview Methods

Postcards were used in both watersheds to encourage participation in interviews regarding farming and water quality. In the Embarras watershed, 47 postcards were returned out of 650 sent to all agricultural landowners (identified by merging publically accessible parcel ownership data with watershed boundary file). In the Upper Salt Fork watershed, 17 of 270 postcards sent with the mail survey packet were returned by those willing to be interviewed. Additional participants were identified using snowball sampling, whereby participants were asked to identify additional people to interview. Some of the postcard respondents were not available. A total of 39 interviews were completed with Embarras farm operators and landowners in the spring 2012, and 14 interviews were conducted in the Upper Salt Fork watershed in spring 2013. Interviewees represented a diverse set of farm operators and landowners from different sized farms and ownership characteristics. Interviews were conducted until a saturation point was achieved in which few new insights were found.

Interview questions focused on farming experiences and practices and perspectives on water quality. Interviews were analyzed thematically across the various research questions and read by three researchers to assure reliability in conclusions drawn. An additional Q-sort activity was conducted with the Upper Salt Fork interview participants to gather information on factors influencing farm decision-making. Q-methodology allows for a form of factor analysis based on participants' subjective ranking of statements. In this study, participants sorted 23 cards stating possible farm decision factors (see Supplemental Information for list of statements used in the Q-sort). After initially sorting factors into high-, medium-, or low-influence categories, the cards were sorted again from least to most influential (with corresponding values from −3 to +3). A picture recorded each template of sorted cards. Data were entered and analyzed using PQ Method Software for descriptive statistics and factor analysis (Watts and Stenner, 2012).

We were more successful than most similar efforts in reaching farm operators using survey research methods (Pennings et al., 2002). For the Embarras, 116 surveys were returned out of 336 sent, minus 30 deemed ineligible due to watershed boundary error and 8 undeliverable addresses, yielding a 38.9% response rate. For the Upper Salt Fork, 90 completed surveys were returned out of 284 surveys sent, minus 13 returned for ineligibility and 1 undeliverable address, yielding a 33.3% response rate. Although limiting in terms of representation, these rates are higher than similar recent studies (e.g., 21.9%, as reported by Reimer and Prokopy [2013]). Comparisons were made with agricultural census statistics for the two counties and the state of Illinois (Table 1). Survey respondents were broadly representative in terms of gender, age (though slightly older), and average farm acreage. Smaller farms (1–99 acres) were underrepresented, as were farms income less than \$49,999. Larger farms yielding greater income were overrepresented, and survey respondents were more highly educated than state agriculture statistics indicate. In the findings presented below, we explore differences between the two watersheds: (i) those with majority of acres owned versus rented and (ii) those farming large (>500 acres) versus small (≤499 acres) farms.

Results and Discussion

Assessments of Water Quality

The Embarras and Upper Salt Fork rivers have typical nitrate concentration patterns of flashy, tile drained, headwater watersheds in the upper Midwest, with high concentrations during winter and spring and low concentrations (approaching 0 mg N L^{-1}) during the low-flow periods of summer and fall (Fig. 1). Nitrate concentrations typically reach about 14 mg N L^{-1} each year in the Embarras River, whereas the Upper Salt Fork typically has peak concentrations of approximately 12 mg N L^{-1}. Both watersheds had near record-high flows on 18 Apr. 2013 and had the greatest nitrate concentrations in our period of record for each watershed in early June 2013 (17.9 and 14.3 mg N L^{-1} for the Embarras and Upper Salt Fork Rivers, respectively). These record nitrate concentrations followed the drought year of 2012, when Champaign County had average corn yields of only 5.9 Mg ha^{-1}, compared with an average of 9.3 Mg ha^{-1} for 2002 to 2011 (USDA-NASS, 2014). The flow-weighted mean concentration of nitrate in the Embarras River for 2013 was 11.7 mg N L^{-1}, which was the largest value in our period of record. These rivers often have nitrate concentrations greater than the USEPA drinking water standard of 10 mg N L^{-1}. No trend in nitrate concentrations ($p = 0.53$) was found for the 22 yr record of the Embarras River using the seasonal Kendall test for trend.

The long-term average water yield for the Embarras River watershed during 1993 to 2013 water years was 35.3 cm of flow, leading to the export of 30.6 kg N ha^{-1} yr^{-1} (Fig. 2). During the past 5 water years, the Embarras River had an average of 36.3 cm of flow with a nitrate yield of 29.8 kg N ha^{-1} yr^{-1}. The Upper Salt Fork River had corresponding values for the past 5 yr of 35.6 cm of flow and 23.0 kg N ha^{-1} yr^{-1}. Although the watersheds have similar runoff, the Embarras River has greater nitrate yields. However, the pattern of nitrate loss was nearly identical; when cumulative daily nitrate load of the Embarras River was regressed against cumulative daily load of the Upper Salt Fork (15 Apr. 2008 through 30 Sept. 2013), the linear regression equation

Table 1. Survey respondent comparisons for the Embarras River and Upper Salt Fork Watershed with county and statewide agricultural census statistics.†

	Survey respondents‡		Ag census county statistics		
	EMB watershed	USF watershed	Douglas County	Champaign County	Illinois
Gender					
Male	95.5%	97.6%	94.7%	90.7%	90%
Female	4.5%	2.4%	5.3%	9.3%	10%
Average age, yr	60.1	59.7	54.7	57.6	56
Farm size, acres					
1–99	15.5%	10.3%	56.0%	42.6%	50.7%
100–499	32.7%	46.0%	21.8%	30.1%	28.3%
500–999	24.5%	23.0%	8.8%	14.9%	10.8%
1000–1999	19.1%	18.4%	8.7%	9.3%	7.2%
≥2000	8.2%	2.3%	4.7%	3.1%	3.0%
Average acreage	374	340	398	396	348
Farm income					
<\$10,000	4.2%	0%	40.6%	27.2%	46.9%
\$10,000–49,999	9.5%	6.7%	16.3%	17.9%	14.7%
\$50,000–99,999	11.6%	18.7%	9.0%	11.5%	8.1%
\$100,000–499,000	47.4%	49.3%	21.4%	30.7%	21.0%
≥\$500,000	27.4%	25.3%	12.6%	12.7%	9.3%
Education					
Some high school	0.9%	2.3%	NA§	NA	13.5%
High school graduate	24.3%	30.2%	NA	NA	37.3%
Some college	38.7%	46.5%	NA	NA	32.3%
College degree	28.8%	19.8%	NA	NA	17%
Postgraduate college	7.2%	1.2%	NA	NA	NA

† Sources: USDA ERS 2007 county and statewide data; education level for Illinois from USDA ERA (Illinois Fact sheet 2007–2011 rural data).

‡ EMB, Embarras River; USF, Upper Salt Fork Watershed.

§ Not applicable.

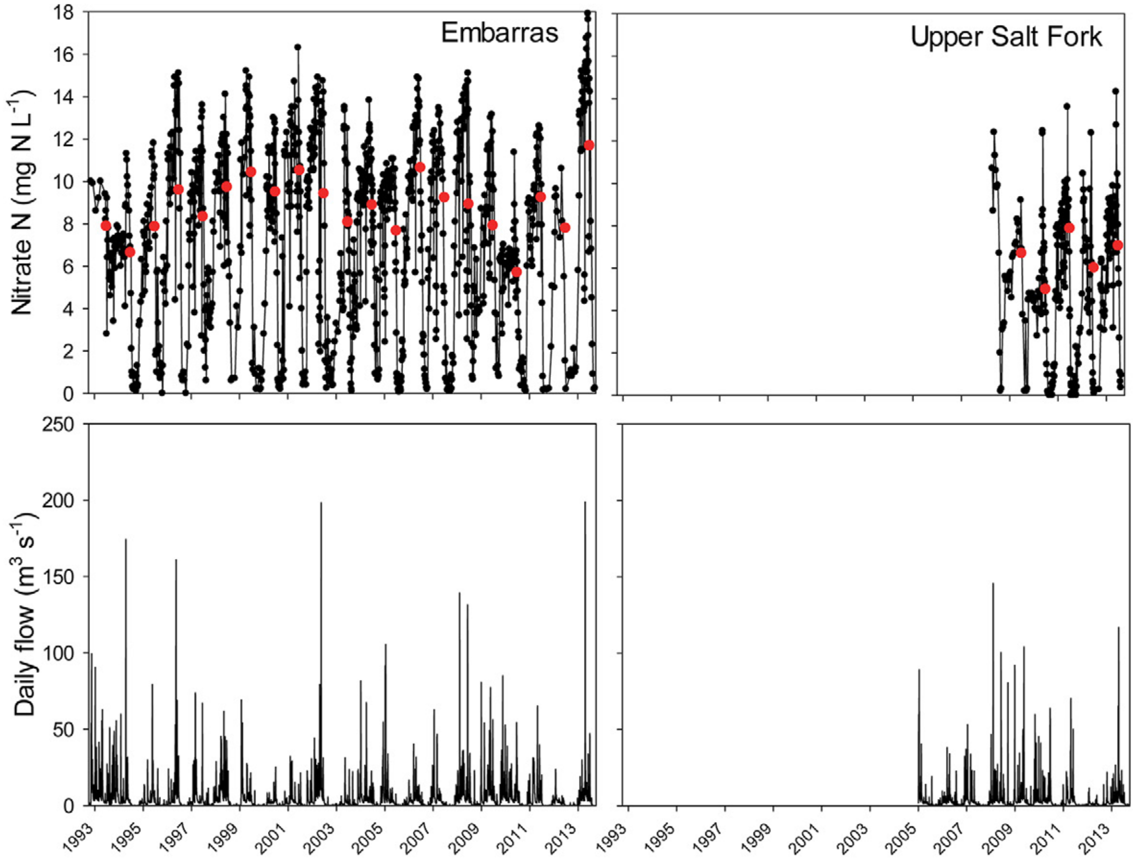

Fig. 1. Daily stream flow and nitrate concentrations in the Embarras River at Camargo, IL, and the Upper Salt Fork River at St. Joseph, IL. Flow-weighted annual nitrate concentrations are indicated with red dots.

explained 99.7% of the variation ($p < 0.0001$). Royer et al. (2006) also noted that watersheds in east-central Illinois have similar patterns of loss and discussed the importance of high flow periods and limited in-stream removal of nitrate. The difference in watershed yields of nitrate in the Embarras and Upper Salt Fork may be due to the density of tile drainage, subsurface flow paths, amount of fall fertilizer N application, fertilization rates, or other unknown differences between the two watersheds. However, both watersheds have large nitrate losses when viewed across the Mississippi River basin, and these loads are consistent with those estimated by David et al. (2010), where the tile-drained Corn Belt has the greatest nitrate losses in the Mississippi River basin. Watersheds such as the Embarras and Upper Salt Fork would be targeted for 45% reductions in nitrate loads as described in the federal action plan for reducing hypoxia in the Gulf of Mexico (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008). Similar to nitrate concentrations in the Embarras River, no trend was found in nitrate yield through time in the Upper Salt Fork using linear regression ($p = 0.76$).

Farm operators generally rated water quality conditions as neither "very poor" nor "excellent" (Table 2). The average water quality rating for ditches and streams in the watershed was 3.32 on a scale from 1 (very poor) to 5 (excellent); Upper Salt Fork respondents were significantly more likely to rate their water quality higher than Embarras respondents. Regarding potential sources of water quality problems, only a small proportion of respondents (18.4%) rated nitrogen a problem (4 or 5 on a scale of 1 to 5). Only two potential sources of problems, sediments (23.4%) and municipal discharge (22.4%), were rated higher than nitrogen as a problem, and phosphorus was indicated as a problem by 15.6%. Approximately 16 to 20% of respondents indicated they did not know if the above sources were a problem for water quality.

Levels of concern about water quality in watershed ditches and streams were moderate, with an average score of 3.30 on a scale from 1 to 5 (not at all concerned to very concerned), although owners were found to be more concerned than renters (Table 2). Comparing concern at various geographic scales, there was little variation from home to the Gulf of Mexico, although the drainage district and watershed were the focus of greater concern than other scales. Farmers rated the Gulf of Mexico no less or more important than water quality concern for their own farm. There were no differences by watershed, farm size, or ownership for geographic scales of water quality concern. These findings address the second research questions and indicate that, although nitrate levels measured in the study watersheds exceeded common standards, fewer than 20% of farmers in the study perceived nitrates to be problematic for water quality.

Assessments of Nitrogen Management Conservation Practices and Adoption Factors

Drainage Water Management

In 2012, DWM was applied for 70 d on NT, and ST was managed as free drainage (FD). The outlets levels were set at 40 and 120 cm from the soil surface for the DWM and FD fields, respectively. The water level in the DWM tile was an

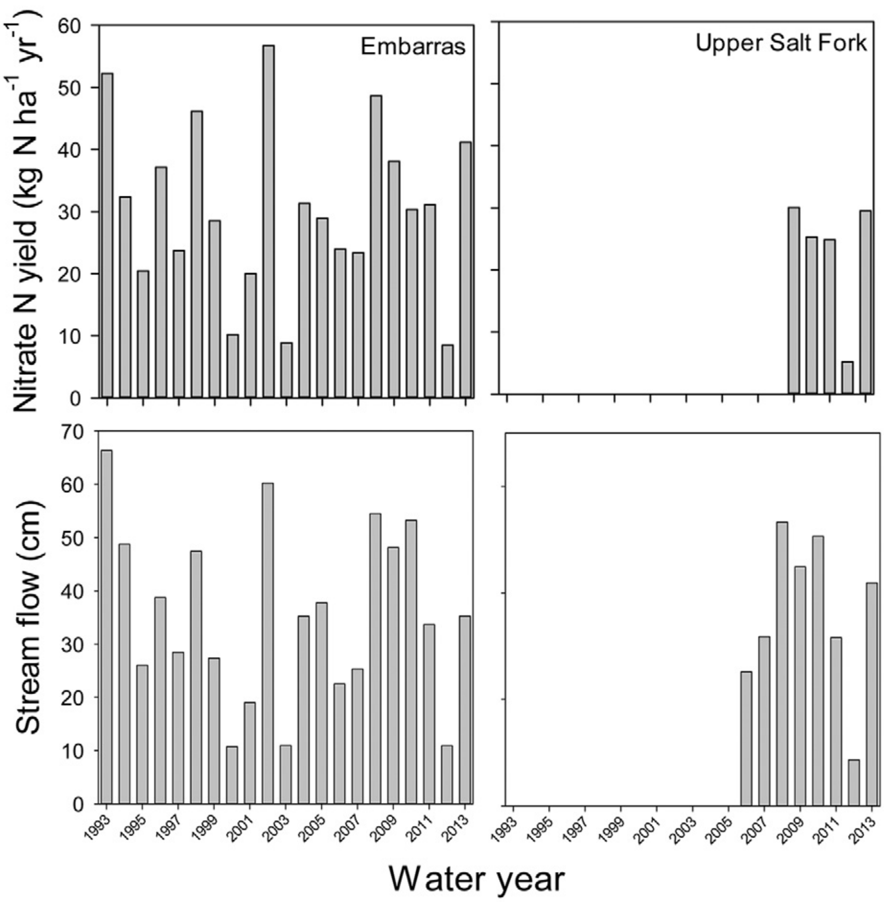

Fig. 2. Annual nitrate N yields and stream flow in the Embarras River at Camargo, IL, and the Upper Salt Fork River at St. Joseph, IL.

tile systems was 10.0 cm of runoff for the water year, clearly showing that water moved from NT to ST. A closer look at the instantaneous tile flow data revealed that the flow in ST increased shortly after initiating DWM on NT, suggesting that tile water was moving laterally from one tile system to the other. The base flow was elevated in the FD tile during the entire period of DWM.

Tile nitrate concentrations varied little between the two tile systems, with concentrations near 10 mg N L^{-1} for the entire winter and spring (Fig. 3). Additionally, tile nitrate concentrations remained relatively constant before and after the period of DWM, suggesting that field denitrification was not an important N sink.

Overall, we found no reduction in tile nitrate load using DWM due to lateral seepage of water to the adjacent system. This brings up new questions about how this technique could improve water quality using some existing tile drainage systems. However, the affected area on the NT was only about 2 ha, well below the recommended affected area size of 8 ha. Most studies to date on DWM have been on small (<5 ha) experimental fields (Skaggs et al., 2012), with the exception of Cooke and Verma (2012). Cooke and Verma (2012) used larger fields but did not determine the flow path of the held back water. There has been no study to date (other than modeling) that has documented the fate of the held-back water and nitrate in DWM systems, and this remains a major limitation to our understanding of this management tool.

average of 70 cm from the soil surface, and water was held back in the field during the entire study period, with the exception of a rain event that occurred on 2 March, which was the only flow event observed during DWM (Fig. 3). In the FD field, there was continuous tile outflow. There was 20,428 m^3 of flow from ST (18.7 cm) and 17,472 m^3 from NT (7.6 cm) in the DWM tile. Although water was held back in NT, flow was increased in ST. Predicted flow (from nearby tile A) from both

Table 2. Embarras River and Upper Salt Fork Watershed water quality perception perspectives.

	$\bar{x}$	SD	Watershed comparison	Influence by size or ownership
Rating of water quality in ditches and streams in watershed (1 = very poor; 5 = excellent)	3.32	0.85	t = 6.31†***	NS
Level of concern about water quality in ditches and streams in watershed (1 = not at all concerned; 5 = very concerned)	3.30	1.19	NS	t = 2.63‡**
Geographic scales of concern (1 = not at all concerned; 5 = very concerned)				
Home	3.10	1.50	NS	NS
Farm	3.09	1.41	NS	NS
Drainage district	3.20	1.30	NS	NS
Watershed	3.20	1.20	NS	NS
Wabash River	3.04	1.17	NS	NS
Mississippi River	3.11	1.20	NS	NS
Gulf of Mexico	3.09	1.23	NS	NS

** Significant at the 0.01 probability level.

*** Significant at the 0.001 probability level.

† Upper Salt Fork Watershed farm operators more likely to rate water quality condition higher than the EMB farm operators.

‡ Owner operators were more likely to indicate higher level of concern of water quality issues than renters.

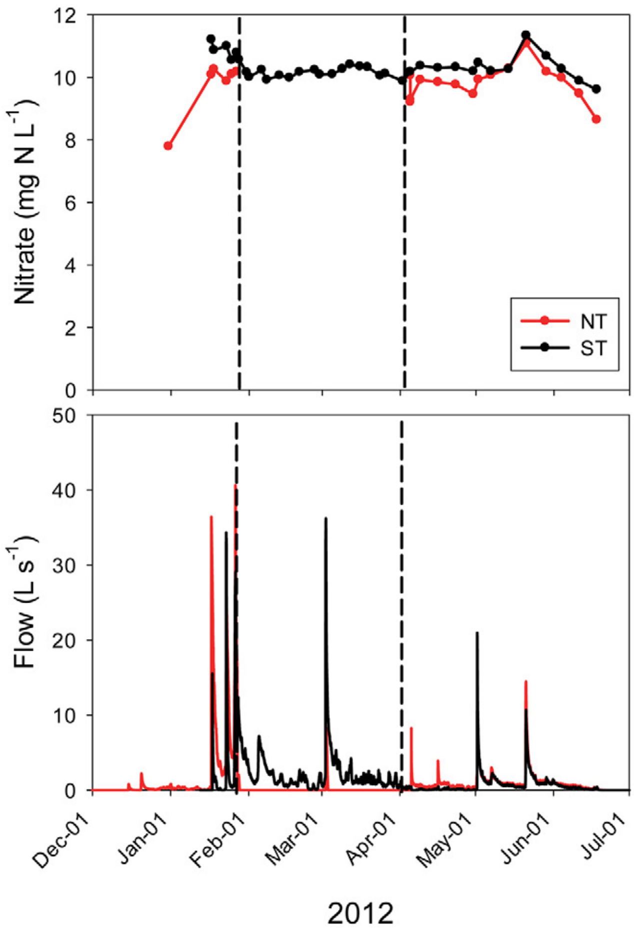

Fig. 3. South tile (ST) and North tile (NT) nitrate concentrations and tile flow during 2012. Vertical dashed lines show period of drainage water management on NT.

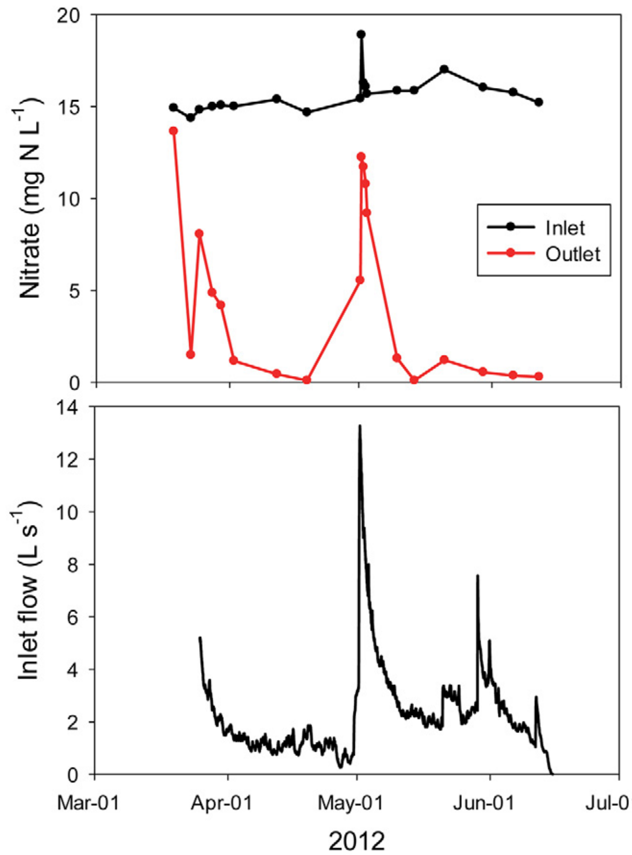

Fig. 4. Tile nitrate concentrations and flow of the inlet to the bioreactor, along with outlet concentrations during 2012.

Wetlands and Bioreactors

End-of-tile and edge-of-field remediation techniques, such as constructed wetlands and woodchip bioreactors, use the microbial process of denitrification to remove nitrate from tile drainage water. Kovacic et al. (2000) found that constructed wetlands designed to intercept tile drainage water removed 45% of the tile nitrate ($n = 9$ wetland water years). Although these initial results were promising, there have been no new wetlands constructed in these watersheds since this study was published. Compared with wetlands, woodchip bioreactors are less expensive to install, have a much smaller footprint, and can fit into grassed riparian buffers without taking land out of row crop production.

In 2012, the newly constructed bioreactor performed well with an 80% nitrate removal rate (257 kg N in, 51 kg N out with 38 kg of this N as by-pass flow); however, the spring was unseasonably warm with little precipitation. Lack of rainfall limited tile flow and ultimately produced a severe drought in this region of the state. During this dry year, only 14% of the total tile flow bypassed the woodchips, which occurred during the week after high flow on 1 May (Fig. 4). Based on a volume of 117 m^3, the nitrate removal rate was 21 g m^{-3} d^{-1}, which is one of the highest removal rates reported for woodchip denitrification sinks (Schipper et al., 2010). Overall, bioreactor performance depends on the balance between residence time and the amount of bypass flow; the lack of rainfall and tile flow during the spring of 2012 created favorable conditions for nitrate removal.

Fertilizer Timing

Tile nitrate concentrations from two production systems (C–C with split application of fall and spring N vs. C–S with split application of spring and side-dress N) were compared, which are both widely used in our two study watersheds (Fig. 5). During the first 2 yr of this investigation, there were

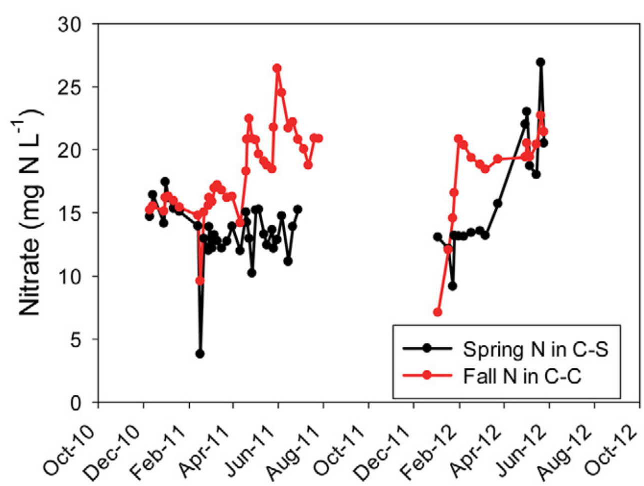

Fig. 5. Continuous corn (C–C) and corn–soybean (C–S) tile nitrate concentrations during 2011 through 2012. For the C–S, corn was grown in 2010 and 2012, and soybean was grown in 2011.

greater tile nitrate yields in the C–C system compared with the C–S system (54 vs. 38 kg N ha^{-1} in 2011 and 15 vs. 11 kg N ha^{-1} in 2012). It is not surprising that tile nitrate yields were greater from the C–C system than the C–S system because no fertilizer was applied during the soybean year in C–S in 2011. However, numerous studies have shown that fall and winter applications of fertilizer N can lead to increased tile nitrate losses compared with spring applications (Welch et al., 1971; Frye, 1977; Gentry et al., 1998; Randall et al., 2003; Clover, 2005). After corn in 2010, nitrate concentration in both tiles tracked one another until a large precipitation and tile flow event on 16 Feb. 2011. From that point onward until tile flow ceased in July, tile nitrate concentrations from the field that received fall N application were greater than the field and tile system that remained unfertilized in 2011. The field that received fall N fertilizer had tile nitrate concentrations that reached 20 mg N L^{-1} 2 mo earlier than the year before (February 2012 vs. April 2011). This is likely due to the effect of unseasonably warm winter temperatures on the effectiveness of the nitrification inhibitor. During flow events after spring fertilization in C–S in 2012, however, both tiles had about the same nitrate concentrations, demonstrating how quickly tile nitrate can respond to fertilizer application.

Cover Crop

Dry conditions during the growing season of 2012 limited corn yield and N uptake, leaving large soil nitrate pools after crop harvest. Rainfall before aerially seeding the cover crop in September allowed for immediate germination and 100% ground cover. Cover crop aboveground biomass and N accumulation were 2 Mg ha^{-1} and 65 kg N ha^{-1}, respectively. The cover crop appeared to have the greatest effect on tile nitrate during high flow events in the winter and spring, suggesting that cover crop N accumulation in the fall reduced the amount of soil nitrate available for leaching. Based on the difference in annual nitrate yields from the paired fields in 2012, we estimated that the cover crop reduced the tile nitrate yield by 34% (Fig. 6). Cover crops have long been used to protect the soil from erosion; however, few studies have investigated the impact of cover crops on tile nitrate losses. Although Qi et al. (2011) did not detect a reduction in tile nitrate yield with a rye cover crop, Strock et al. (2004) found a modest reduction in tile nitrate yield of 13%, whereas Kaspar et al. (2007) found large tile nitrate reductions (59%) using rye as a winter cover crop. Cover crops may be the only practice that can reduce both erosion and tile nitrate yields.

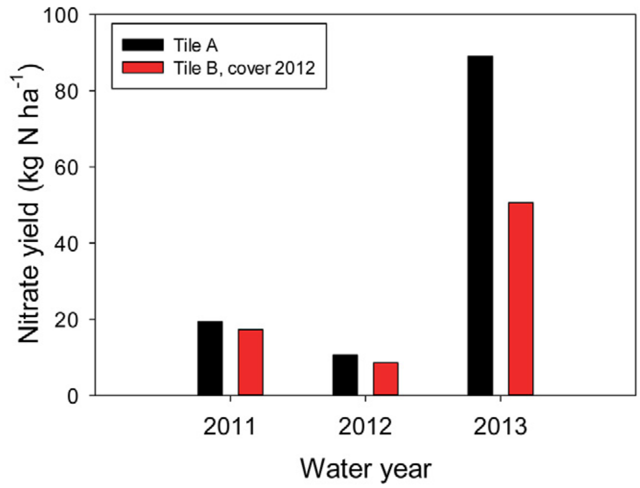

Fig. 6. Nitrate yields from tile drains in two fields during 2011 through 2013. Tile B had a cover crop planted in the fall of 2012. The 2011 water year was a partial year, with data from 1 April through 30 Sept. 2011.

Survey Results

Survey findings about the current use of various water quality–related practices are shown in Table 3. The majority of surveyed farmers indicated they conducted regular soil tests, followed a nutrient management plan, followed university-recommended fertilization rates, and used variable-rate application technology. Farmers of larger farms and renters were more likely to use these practices than those farming smaller farms or owning the majority of their farm acreage. In contrast, hardly any respondents indicated using practices specific to managing nutrients, such as cover crops, wetlands, controlled drainage, or bioreactors.

For farmers who did not indicate current use of the practices discussed above, a majority were familiar with the commonly used practices but less familiar with cover crops, wetlands, controlled drainage, and bioreactors, with about half of the respondents indicating they had never heard of bioreactors (Table 4). Watershed differences for controlled drainage and bioreactors

Table 3. Embarras River and Upper Salt Fork Watershed survey responses about currently used conservation practices.

	Currently use it	Watershed	Influence by size or ownership
	%		
Conduct regular soil test	84.9	NS†	χ2 = 15.31‡***; χ2 = 9.39§**
Follow a nutrient management plan	61.0	NS	χ2 = 5.11§*
Follow university fertilization rates	54.6	NS	χ2 = 19.12‡***; χ2 = 4.82§*
Use variable-rate application technology	54.6	NS	χ2 = 20.38***; χ2 = 6.43§*
Cover crops	9.4	NS	NS
Wetlands	5.9	NS	NS
Controlled drainage	5.6	NS	χ2 = 5.13‡*
Bioreactors	0.5	NS	NS

* Significant at the 0.05 probability level.

** Significant at the 0.01 probability level.

*** Significant at the 0.001 probability level.

† Not significant.

‡ Farmers of larger farms more likely to use practice than farmers of smaller farms.

§ Renters more likely to use practice than owner operators.

Table 4. Embarras River and Upper Salt Fork Watershed level of familiarity with conservation practices that respondents were not currently using.

	Currently not using and			Watershed	Influence by size or ownership
	Never heard of it	Somewhat familiar with it	Familiar with it		
	%				
Conduct regular soil test	3.3	30.0	66.7	–	–
Follow a nutrient mgmt. plan	5.3	53.9	40.8	–	–
Follow university fertilization rates	10.1	36.0	53.9	–	– NS (ownership)
Use variable-rate application technology	6.7	19.1	74.2	–	–
Cover crops	25.4	31.8	42.8	–	χ^2 = 11.25†** NS (ownership)
Wetlands	15.3	41.5	43.2	NS	NS
Controlled drainage	21.0	35.5	43.5	χ^2 = 34.69‡***	NS
Bioreactors	50.8	26.5	22.8	χ^2 = 13.72§**	χ^2 = 6.09¶* NS (ownership)

* Significant at the 0.05 probability level.

** Significant at the 0.01 probability level.

*** Significant at the 0.001 probability level.

† Farmers of larger farms more likely to be familiar with cover crops than farmers from smaller farms.

‡ Embarras River farm operators more likely to be familiar with controlled drainage than Upper Salt Fork Watershed farm operators.

§ Embarras River farm operators more likely to never have heard of bioreactors than the Upper Salt Fork Watershed farm operators.

¶ Farmers of smaller farms more likely to have never heard of cover crops than farmers of larger farms.

are likely explained by varying degrees of local engagement by professionals regarding these practices. Farmers of larger farms were generally more familiar with cover crops and bioreactors than those of smaller farms. However, limitations in the size of the dataset warrant caution in interpretation of the data.

Respondents indicated a relatively high level of interest in new agricultural practices for production and conservation (Table 5). Renters showed more interest than owners in new practices for production, and farmers of larger farms had more interest in practices for production and conservation than those farming smaller farms. In addition to assessing current use, familiarity, and general interest regarding various practices, the survey assessed factors influencing or constraining adoption of new water quality management practices (Table 6). The first battery of questions asked about the importance of various issues when making water quality management decisions. All stated factors were rated above 4.00 on a scale of 1 to 5. The top factor with a mean of 4.40 was "improving or maintaining the condition of my farm for future generations of farmers." This was followed by "improving my farm production" and "improving my bottom line."

"Personal out-of-pocket expense" (mean of 3.49 on a scale of 1 to 5) was the highest rated factor seen to limit the ability to implement water quality management decisions. This was followed by "lack of government funds for cost share," "concerns about reduced yields," and "possible interference with my flexibility to change land use practices as conditions warrant." Embarras respondents were more likely to indicate the limitations of "lack of government funds for cost share" than Upper Salt Fork respondents. Farmers of smaller farms were more likely to indicate limitations related to "no one else I know is implementing the practice" and "approval of my neighbors," suggesting they are possibly more influenced by social dynamics than farmers of larger farms. As for what circumstances would influence willingness to modify farm operation to improve water quality, respondents rated "if you saw convincing evidence from local demonstration plots that modifications would increase nutrient loss" highest (mean of 3.68 on a scale of 1 to 5 on willingness). This was followed by "if financial incentives were provided to cooperating farmers" (mean, 3.57). The lowest-rated factor related to circumstances influencing willingness to modify farm operation to improve water quality was "if federal or state regulations were established governing water quality of agricultural runoff" (mean, 2.79).

Table 5. Embarras River and Upper Salt Fork Watershed survey responses regarding interest in new agricultural practices for their farm (1 = not interested; 5 = very interested).

	$\bar{x}$	SD	Watershed comparison	Influence by size or ownership
For production	4.11	0.99	NS	$t = -2.37$†*; $t = -3.21$‡**
For conservation	3.93	1.01	NS	$t = -2.71$‡**

* Significant at the 0.05 probability level.

** Significant at the 0.01 probability level.

† Renters more interested in new practices for production than owner operators.

‡ Farmers of larger farms more interested in new practices for production and conservation than farmers of smaller farms.

Findings from surveys of farm operators shed light on the fourth research question about adoption of conservation practices, suggesting there are substantial barriers to adoption of specific water quality conservation practices that would help address nitrate problems in intensively farmed watersheds. These barriers include social and informational factors as well as oft-cited financial limitations. The data also show that just establishing policies to regulate water quality may not increase adoption of particular practices.

Assessments of Complexity Regarding Nutrient Management and Farm Decision-Making

Each of the in- and edge-of-field N management techniques we evaluated had biophysical and social constraints. David et al. (2013) briefly summarized some of these constraints, and this study has illustrated the constraints in some detail. Weather (frequency and intensity of precipitation and winter temperatures) is a major limitation for edge-of-field N management methods. There has been an increased frequency of intensive precipitation during the winter and spring in the upper Midwest (MRCC, 2013). The flow event on 19 Apr. 2013 (13 cm of precipitation during 15–18 Apr. 2013 [Fig. 1]) would overwhelm any wetland or bioreactor. Kovacic et al. (2000) indicated that large storm flows where the river inundates the wetland created periods of no nitrate removal. The April 2013 storm did inundate the wetlands and bioreactor such that they had no nitrate removal (data not shown). Given that most of the nitrate load is transported down river during these major storm events in the winter and spring (Royer et al., 2006), edge-of-field methods cannot be designed with a large enough capacity to reduce these loads. Increased winter temperatures (Villarini et al., 2013) lead to greater winter and early spring tile flow, where techniques such as wetlands and bioreactors that depend on microbial denitrification for nitrate reduction have slow rates of removal.

For the watersheds of east-central Illinois, there are many landscape-level limitations for placement of many nutrient reduction techniques. Woodchip bioreactors, for example, fit best into existing filter strips located along ditches and streams. However, at current commodity prices, many conservation areas (e.g., filter strips) are returning to row crop production on contract expiration, which will further constrain suitable sites for bioreactors. In general, by the time a tile line outlets into a ditch, it may have passed through multiple fields with multiple landowners and may have drained hundreds of hectares of land.

Table 6. Embarras River and Upper Salt Fork Watershed survey factors influencing water quality management decisions.†

	$\bar{x}$	SD	Watershed comparison	Influence by size/ownership
Importance of issues when making water quality management decisions on farm (1 = not at all important; 5 = very important)				
Improving my farm production	4.25	0.91	NS	NS
Improving my bottom line	4.24	0.94	NS	NS
Improving the quality of water	4.14	0.90	NS	NS
Promoting conservation	4.14	0.79	NS	NS
Improving or maintaining relationships with neighboring farmers	4.10	0.93	NS	NS
Improving/maintaining appearance of my farm	4.08	0.98	NS	NS
Improving or maintaining the condition of my farm for future generations of farmers	4.40	0.84	NS	NS
How much issues limit ability to implement water quality management decisions on farm (1 = not at all; 5 = a great deal)				
Personal out-of-pocket expense	3.49	1.27	NS	NS
Lack of government funds for cost share	3.39	1.28	t = 2.73‡**	NS
Not having access to the equipment that I need	3.09	1.21	NS	NS
Lack of available information about a practice	2.96	1.18	NS	NS
No one else I know is implementing the practice	2.74	1.21	NS	t = 3.60§***
Concerns about reduced yields	3.38	1.35	NS	NS
Approval of my neighbors	2.52	1.32	NS	t = 2.40§*
Don't want to participate in gov. programs	2.51	1.26	NS	NS
Requirements or restrictions of gov. programs	3.31	1.29	NS	NS
Possible interference with my flexibility to change land use practices as conditions warrant	3.34	1.24	NS	NS
Environmental damage caused by the practice	3.08	1.24	NS	NS
I do not own the property	2.93	1.51	t = 2.88‡**	NS
Not being able to see a demonstration of the practice before I decide	3.03	1.23	NS	NS
Willingness to modify farm operation to improve water quality under the following circumstances (1 = not at all willing; 5 = very willing)				
If federal or state regulations were established governing water quality of agricultural runoff	2.79	1.15	NS	NS
If financial incentives were provided to cooperating farmers	3.57	0.97	NS	NS
If most neighboring or family farmers adopted water quality improvement management practices	3.29	0.97	NS	NS
If you saw convincing evidence from local demonstration plots that modifications would increase nutrient loss	3.68	0.92	NS	NS
If recommended by your county Farm Bureau	2.90	0.96	NS	NS
If recommended by your county Soil and Water Conservation District	3.24	0.92	NS	NS
If recommended by University of Illinois Extension	3.08	0.99	NS	NS

* Significant at the 0.05 probability level.

** Significant at the 0.01 probability level.

*** Significant at the 0.001 probability level.

† Questions were adapted and modified from the Social Indicator Planning and Evaluation System (see Genskow and Prokopy [2011]).

‡ Embarras River farm operators rated greater limitation than Upper Salt Fork Watershed farm operators.

§ Farmers of smaller farms rated greater limitation than farmers of larger farms.

Based on the footprint-to-nitrate removal ratio, bioreactors cannot effectively treat large tile flow volumes from these extensive tile systems. On the other hand, constructed wetlands can be designed large enough to accommodate these extensive tile systems and to intercept overland runoff. However, constructed wetlands have a much greater footprint than do bioreactors and are best positioned below an adjacent field within a natural floodplain. In areas covered by the most recent glacial episode (the Wisconsinan glaciation), stream drainage networks are relatively immature and floodplains are not well developed, which greatly limits the potential for siting treatment wetlands on many tile systems. In fact, most drainage ditches did not exist before they were carved out of the flat landscapes by the steam shovel in the late 1800s, which created mounds of dredge spoil on both sides of the ditch. This situation makes siting a bioreactor a challenge due to the depth of the tile as it passes from field to ditch and renders siting a wetland impossible due to lack of slope in these areas.

Drainage water management works best when implemented on new tile systems designed for this capability (Ehmke, 2013). Our implementation on an existing tile system documented movement of the held-back water from the DWM system to the nearby free drainage system. Perhaps this was not a suitable field for retrofit of DWM, but we had few choices when looking for cooperators as few landowners wanted to be part of this study, even when there was no cost.

In-field techniques, such as fertilizer timing and cover crops, may have the best chance for broad implementation and may reduce nitrate losses before it reaches the tile line. Given the weather constraints discussed previously, this is a great advantage. Fertilizer timing has few costs but can increase risks for corn production. Cover crops add costs and management complexities. For the Upper Salt Fork Watershed, attempts have been made through NRCS and the American Farmland Trust, and more recently through the fertilizer industry, to greatly expand cover crop use (with full cost share). There have been few acres enrolled to date, likely because of the many economic and social constraints acting on farmers and landowners in this watershed. This watershed has excellent soils that produce high yields, and when combined with high grain prices this may limit interest in practices that might be viewed as having a potential negative effect on yields.

Interviews with farm operators and landowners highlighted the complex issues affecting farming. Participants described economic, environmental, and social factors influencing their ability or willingness to adopt new practices to improve water quality. Some respondents indicated "bottom line" and input costs as motivating factors:

> "Well, and most farmers, they're going to do what, you know, they want to make enough money to do it again next year. That's the first thing, and then, you know, if it's good for water quality so be it. But, you know, it usually boils down to money."

> "Well the cost of it and implementation would be a big factor for us. Everybody wants better water quality but you have to see the cost associated with those things that you would do. So the economical to me would be the primary concern I guess."

However, other farmers reflected that environmental considerations might outweigh the economic in some circumstances as indicated by these quotes:

> "If there was a practice that showed a great economic return, but yet resulted in, losing nitrogen, or losing nutrients or, you know, something that was really bad for water quality, I would think twice about it."

> "Well, conservation in the idea of saving the soil that we have, so that you don't get erosion, that part of it, yes. That would be my first concern."

Interviews also revealed strong social dimensions to decision-making in terms of future generations and the influence of observing the actions of others, as indicated by these quotes:

> "I've got sons and grandsons that I think will want to farm and what's it going to be like in 70 years if we don't start taking care of some of the issues now?"

> "I think most of the farmers are like sheep, one leads, the rest of them follow. My dad's 84 years old and I had a hard time convincing him to no-till corn, but after he saw it could be done and the results, boy now he wouldn't have it any other way."

The Q-sort activity shed additional light on the complexity of farming, revealing, at least preliminarily, that there is heterogeneity among farmers in terms of what influences overall farm decision-making. The factor analysis of 23 sorted farm decision-making factors revealed four factors with Eigenvalues over 1, explaining 54% of the total variance across participants. There were no key differences in farmer characteristics (farm size, ownership, age). The factor arrays of the statements sorted indicated how the farm decision factors clustered among the participants. Eleven of the 14 farmers fell into one of four thematic groups, identified based on factors with eigenvalues above or close to 1.0. Groups of farmers with similar sorting patterns were found to fall into the following categories of dominant decision-making influence: (i) Economics and Information, (ii) Family Oriented and Environmentally Conscious, (iii) Water Quality Concern, and (iv) Agricultural Focus.

The Economics and Information factor explained 22% of the total variance and influential statements for this group were bottom line, increased crop yield, access to information, and supportive evidence from science. The Family Oriented and Environmental Conscious factor explained 16% of the total variance, and influential statements were future generation farming, soil erosion, and family farming history. The Water Quality Concern factor explained 11% of the total study variance, and influential statements were water quality impacts from tile, water quality impacts from surface runoff, and promoting conservation. Finally, the Agricultural Focus factor explained 5% of the total variance in the study and included three highly rated statements about commodity market prices, land ownership, and availability of technology. The Q-methodology is helpful for disentangling the heterogeneity among farmers. However, although designed explicitly for small sample sizes, 40 to 60 is an oft-cited optimal range according to Watts and Stenner (2012), suggesting that caution may be warranted in interpreting findings based on 14 participants.

Biophysical and Social Science Results Inform Policy Decisions

Our biophysical and social studies of the Upper Salt Fork and Embarras River watersheds demonstrate a disconnect between field and stream measurements and water quality perspectives of farm operators as well as complexity of reducing nitrate concentrations and loads in the river systems. Various in-field and edge-of-field techniques can help to reduce nitrate loads but have limitations and little social acceptance under our current policy and management systems. In addition, large-scale (nearly every field) adoption would be needed for substantial reductions in nitrate yields to occur, as was documented recently in the Iowa nutrient assessment (Iowa Nutrient Reduction Strategy, 2013).

Based on our long-term data set for the Embarras River, we have not observed a significant trend in river nitrate yield during the past 21 yr. It is possible that competing factors are at work and have produced a virtual draw regarding improved water quality in the Embarras River watershed. For example, conservation benefits may be offset by increased tile drainage installations, and gains in N use efficiency may be offset by an increase in corn acreage. If USDA farm subsidy programs continue to reward only crop yield, then gains in N use efficiency will likely be nullified by increases in corn acreage and tile installations; improvements in surface water quality will go undetected in these watersheds.

The inconsistency of findings across studies of conservation adoption (Prokopy et al., 2008), the complexities affecting technical efficacy of new practices, and the combination of factors influencing decision-making found here and by others (Battershill and Gilg, 1997; Maloney and Paolisso, 2006) suggest there is not likely a simple policy or technical solution or policy that would readily solve the nutrient–water quality problem. Priorities are multiple and heterogeneous across the farming community (Atwell et al., 2009a, 2009b), and policies are needed that allow for flexibility under changing socio-economic and physical conditions. Programs that bring farmers together and generate a collective sense of what is needed for improving conservation may also be helpful (McGuire et al., 2013). Without creating new efficiency-based subsidy programs, we will need every farm and every farmer in Illinois actively implementing some form of end-of-pipe remediation practice to address this issue on such a scale. Incentivizing on-farm research and collaborative arrangements among farmers will be increasingly important. Our finding of higher levels of concern for water quality at drainage district and watershed scales suggests that scaling up, or connecting individual and local efforts to meso- or macro-scale policies, programs, and strategies as advocated by Stuart and Gillon (2013) to mitigate collective vulnerabilities and contextualize policies in terms of economic and political realities, is essential.

Conclusions

Two tile-drained watersheds in east-central Illinois had large losses of nitrate, with no trend through time observed in the 21-yr record of the Embarras River. We determined that that fertilizer timing, cover crops, wetlands, and tile bioreactors could reduce these nitrate losses but found problems with DWM that was retrofitted to existing tile systems. Surveys indicated that although landowners and farmers had strong stewardship ethics, financial and operational constraints limited their willingness to adopt conservation practices that specifically targeted nitrate reduction and did not increase yields. With the policy and production systems currently in place on these corn- and soybean-dominated watersheds, large-scale nitrate reductions that are called for in nutrient reduction strategies for the Mississippi River Basin will be difficult to meet.

Acknowledgments

We thank the many farm cooperators who made this study possible, Bruce Stikkers and Renee Weitekamp of the Champaign County Soil and Water Conservation District for assistance with surveys and work with landowners, the Salt Fork Implementation Committee, Nathan Banion for research assistance, and Corey Mitchell for field and laboratory analysis and data summaries. This work was partially funded by the USDA National Institute of Food and Agriculture under agreements no. 2009-51130-06041 and 2011-039568-31127 and by American Farmland Trust. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the USDA. This work resulted from a conference supported by NSF Research Coordination Network award DEB-1049744 and by the Soil Science Society of America, the American Geophysical Union, The International Plant Nutrition Institute, The Fertilizer Institute, and the International Nitrogen Initiative.

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Biophysical and Social Barriers Restrict Water Quality Improvements in the Mississippi River Basin

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The Gulf of Mexico hypoxic zone that was measured in July of 2013 was 15 120 km^2, the result of riverine losses of nitrate and total P from the Mississippi River Basin (MRB). Despite twelve years of an action plan calling for reducing the zone to a five-year running average of 5000 km^2 by 2015, little progress has been made (ref 1, Figure 1). To meet the hypoxic zone target, the 2007 plan called for 45% reductions in total N and total P.[2] There is no evidence that nutrient loading to the Gulf has decreased during this period. Here we discuss the biophysical and social barriers that have limited measurable progress. We suggest that the most viable approach to developing the suite of practices needed to reduce nutrient losses from agricultural fields is a partnership of researchers working closely with farmers to develop realistic practices on real-world farms (where the constraints that influence management are present), to document the effectiveness, and to communicate the environmental and socioeconomic results regionally. To widely implement the resulting nutrient reduction practices will require substantial new funding if we are to continue using our current agronomic production systems in the MRB.

Much of the nitrate that leads to the hypoxic zone formation is lost from millions of acres of fields across the upper Midwest, where drainage has been accelerated by a variety of practices.[3] Many flat agricultural fields are artificially drained with perforated plastic tubing or older clay drainage pipe (tiles) to allow timely field work and enhance crop growth. During recent decades more extensive patterned systems have been installed. There are now tens of millions of acres of tile drained fields, with large losses of nitrate even with the recommended best management practices (BMPs) being followed. Corn acres have also increased during the past decade on this tile-drained landscape, driven by the increase in price due in large part to increased demand for corn for ethanol production.

Changing weather patterns have led to warmer winter temperatures and more frequent intense precipitation during the winter and spring in the upper Midwest, before crop growth makes use of applied nutrients. The combination of expanded and patterned tile drainage, increased fertilizer use due to more corn production, and more frequent high intensity precipitation events all contribute to greater losses of nutrients, and therefore a large hypoxic zone. This occurs even though nutrient balances (inputs minus outputs) have generally improved across the upper Midwest.[3,4]

The USDA Natural Resources Conservation Service (NRCS) promotes and provides technical information on a wide array of techniques that can be used to reduce nutrient losses, including fertilizer rate, timing and placement; cover crops, nitrification inhibiters, water table management, tile bioreactors, constructed wetlands, buffer strips, and conversion of row crops to CRP or perennial crops. However, on tile-drained fields few are used mainly because these practices impose substantial costs and/or risks on the producer, without increasing crop production. For example, end-of-pipe practices such as tile bioreactors or constructed wetlands have substantial construction costs, require land to be taken out of production, and provide no production benefit to the producer. Conversion to CRP or perennial crops can substantially reduce nutrient losses, but are rarely found on fields that have highly productive soils,

Received: September 4, 2013
Revised: September 24, 2013
Accepted: October 4, 2013
Published: October 22, 2013

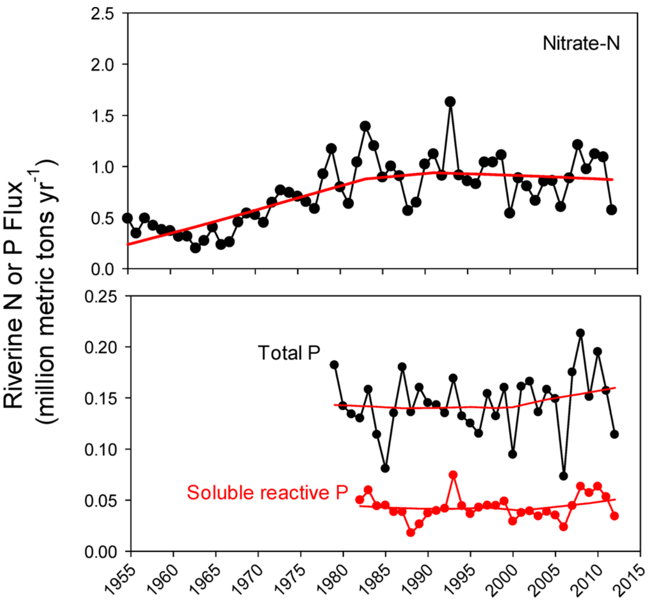

Figure 1. Mississippi River basin annual nitrate-N, soluble reactive P, and total P riverine flux with LOWESS fitted line in red. Adapted from http://toxics.usgs.gov/hypoxia/mississippi/flux_ests/.

are tile drained, and have a large monetary return from corn production. There are landscape level limitations for placement of many of these nutrient reduction techniques. Woodchip bioreactors, for example, fit best into existing filter strips located along ditches and streams. However, at current commodity prices, many conservation areas such as filter strips are returning to row crop production. Finally, most experience with conservation comes from NRCS work to reduce soil erosion, primarily by conservation tillage or no-till. Producers can easily see and recognize that large losses of soil from their fields leads to decreased productivity. However, farmers cannot see the loss of nutrients from tile lines or through surface runoff, so these losses are not readily apparent nor acted on.

Additional and critically important constraints are in the socio-economic realm and relate to factors influencing adoption of farm conservation practices. Producers view themselves as stewards who care for the land, but need to make a living from it. Not only can they not see the loss of nutrients, they are disconnected physically from the downstream effects. Information can influence awareness and concern for water quality, but trust in sources of information and farmers' practical capacity to directly respond are often compromised. Conservation goals are only one of several farm planning considerations, which include production goals, market constraints and opportunities, multigenerational family issues, technical capacity, and weather and climate variations and threats. Stewardship objectives may be strong, but they can be trumped or complicated by other economic, social and environmental drivers. Additionally, there is a growing sense among farmers that policy makers are too far removed from the realities of farming. This leads to an ever-widening trust-gap that is a major barrier to effective collaboration and policy development for water quality improvement in the MRB and beyond.

Policy makers need to further understand that just targeting a small percentage of fields managed by a few "bad" actors will not solve the MRB problem, or that over application of nutrients is the major issue. In areas with steep slopes and concentrated livestock generating manure, a small portion of the landscape coupled with poor production techniques can lead to large losses. Although targeting these few operators and locations with conservation can lead to large reductions, this is not true across the tile-drained MRB. The complexity of reducing nutrients across extensive acres of tile drained corn and soybean fields will take new programs and substantial funding if we are to make large-scale reductions called for in the hypoxia action plan.

Iowa's recently released nutrient reduction strategy[5] demonstrates the billions of dollars needed, and the difficulty that lies ahead in making substantial reductions in riverine nutrient transport. We agree with this view, and believe the best path forward is to have farmers actively participating with researchers to develop realistic suites of practices that could find widespread regional acceptance. We call for more real-world, on-farm longitudinal studies of nutrient loss reduction practices appropriate to overall farm management and land-scape context. However, there still will be a need for considerable funding for cost sharing practice development and implementation. Involvement of farmers is critical to making progress, given the considerable biophysical and social constraints to reducing nutrient losses under which they now operate.

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Notes

The authors declare no competing financial interest.

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