Toward a collaborative model of surface water management: Lessons from the Boone River watershed nutrient management initiative

by

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NOMENCLATURE

ACWA	Agriculture's Clean Water Alliance
BMP	Best Management Practice
BRW	Boone River Watershed
CEMSA	Certified Environmental Management Systems for Agriculture
CPS	Conservation Practice Standard
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
DMWW	Des Moines Water Works
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FFP	Fishers and Farmers Partnership
HUC	Hydrologic Unit Code
IDALS	Iowa Department of Land Stewardship
IDNR	Iowa Department of Natural Resources
ISA	Iowa Soybean Association
ISU	Iowa State University
MRBI	Mississippi River Basin Healthy Watersheds Initiative
NPSP	Non-Point Source Pollution
RC&D	Resource Conservation and Development Council
TNC	The Nature Conservancy
USDA NRCS	United States Department of Agriculture – Natural Resources Conservation Service (NRCS)
USFWS	United States Fish and Wildlife Service

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ABSTRACT

Though productive, Iowa agriculture contributes substantially to nitrogen, phosphorous, and sediment pollution in local surface waters and the Gulf of Mexico. In response to local and national concern over surface water quality, in 2013 the State of Iowa approved the Iowa Nutrient Reduction Strategy and is working to engage Iowa farmers to protect water resources. The Boone River watershed (BRW) initiative in central Iowa was recently designated a demonstration site for the reduction strategy, as diverse public, private, and non-profit partners have been involved in the BRW for over a decade. To inform management decisions in the BRW and other Iowa watersheds, BRW partners commissioned a three-part biophysical and social science evaluation in 2012. As part of this team, I explored social dynamics at multiple programmatic levels to provide feedback on socioeconomic indicators of progress, remaining barriers, and actionable solutions. I conducted and analyzed interviews with 33 program leaders, farmers, and local agronomists and triangulated this primary data against program documents. I then provided program leaders with evaluative reports containing lessons learned and recommendations.

The chapters in this thesis highlight findings of potential interest to other agricultural watershed programs. In Chapter 2 I discuss findings and recommendations related to multi-stakeholder collaboration, including the importance of multi-scale monitoring and evaluation, communication between diverse stakeholder groups, and backbone structures to guide strategic coordination of watershed management outputs. In Chapter 3 I discuss my findings in the context of resilience theory and adaptive co-management. I identified “scale challenges” that act as barriers to long-term, adaptive watershed management, but found that

multi-stakeholder collaboration has enabled BRW partners to remain flexible within a context of rigidity and uncertainty.

CHAPTER 1

GENERAL INTRODUCTION

Surface water quality is an increasingly contentious issue in Iowa. The state is a top contributor of nitrogen and phosphorous to the Gulf of Mexico, where excess nutrients are responsible for algal blooms that cause hypoxic conditions along the Gulf Coast (Alexander et al. 2008, David et al. 2010). Nutrient, sediment, and bacteria pollution in Iowa surface waters are also of local concern; in 2013 the EPA listed 480 Iowa water bodies as too polluted for their designated purpose (IDNR 2012).

The majority of the pollutants in Iowa waters originate from non-point sources, primarily from agricultural land. Multiple studies have demonstrated that fertilizers used in corn and soybean production contribute disproportionately to nutrient loading in the Mississippi River and its tributaries (Booth and Campbell 2007, Alexander 2008, David 2010). Alexander et al. (2008) estimate that 52% of the nitrogen and 25% of the phosphorous reaching the Gulf of Mexico originate from land in corn and soy production.

To address growing local and national concerns regarding water quality, the State of Iowa conducted a science assessment and drafted the Iowa Nutrient Reduction Strategy (Iowa 2013). Completed in 2013, the strategy calls for a 41% reduction in nitrogen and 29% reduction in phosphorous from non-point sources. To meet reduction goals farmers across the state must voluntarily adopt new management practices and cropping systems. However, state agencies and environmental non-profits have struggled for decades to engage farmers in natural resource management and conservation efforts. Critics of the Nutrient Reduction Strategy argue that farmers have to be regulated for Iowa to achieve its water quality objectives. Others fear that a regulatory system will be costly, difficult to enforce, detrimental to farmer well-being, and still fail to meet reduction goals (ISU 2013).

To experiment with voluntary approaches to water quality management, Iowa has selected a handful of "demonstration watersheds" where local stakeholders are already engaged in watershed management. One demonstration site is the Boone River Watershed (BRW) in central Iowa, where diverse public, private, and non-profit organizational partners have been involved in water quality management for a decade. Partner organizations in the BRW manage an extensive water quality monitoring network and work with local farmers to implement water quality management practices. Although partners have different primary objectives and roles, their shared goals are to reduce nutrient loading and improve biodiversity in the BRW while maintaining farmer prosperity.

In 2012 BRW partners received a McKnight Foundation grant to conduct a comprehensive science evaluation of the biophysical and socioeconomic progress associated with the program. They commissioned a science team made up of researchers from Iowa State University and the University of Iowa. The science team was composed of three groups with different research objectives. Dr. Michelle Soupir's group collaborated with Iowa Soybean Association to study hydrological function in one of the HUC-12s in the Boone. Dr. Keith Schilling's team evaluated water quality data for the entirety of the Boone and for other watersheds where BRW partners were involved. Finally, our team investigated program management, communication, and outreach strategies utilized in the BRW. Our objective was to provide partners with a number of evaluative documents outlining lessons learned and actionable recommendations for future implementation efforts.

To understand social dynamics at multiple programmatic scales, we conducted a document analysis and interviewed 33 BRW stakeholders. Our respondents included program partners (n=15), local agronomists (n=4), and farmers (n=14). Through non-probability sampling methods (Neuman 2005) we gained the perspectives of the majority of BRW program leaders and associated agronomists. We also were able to interview farmers with a diverse range of experience with the BRW program. Interviews were coded using NVivo 10 software (QSR 2012) and a grounded theory methodology (Strauss and Corbin 1990, Esterberg 2002). Multiple trained project personnel assisted with the process of data quality assurance and control (QA/ QC) by reading interviews and assisting with theme development, refinement, and interpretation.

Through our data collection and analysis processes we were able to gain in-depth knowledge of program outputs and progress towards intended outcomes. We also explored barriers or gaps that may obstruct program success. We utilized the watershed management and social science literature to inform recommendations based on our findings. Upon completing our evaluation we presented findings and recommendations to program partners through a series of three documents and several meetings.

As work continues in the BRW, partners plan to utilize recommendations from our evaluation to guide program management. Recommendations of possible interest to the broader watershed management community are presented in Chapter 2 of this thesis. Chapter 3 provides an analysis of how BRW partners build resilience within their program and the social-ecological system in which they work.

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CHAPTER 2

TOWARD A COLLABORATIVE APPROACH TO WATERSHED MANAGEMENT: LESSONS LEARNED FROM THE BOONE RIVER WATERSHED, IOWA

A paper to be submitted for publication to the *Journal of Soil and Water Conservation*

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Introduction

Water quality degradation is a problem of local and national concern. Nutrients, sediment, and bacteria from non-point agricultural sources pose a public health risk, reduce biodiversity, and are primary contributors to the hypoxic zone in the Gulf of Mexico. For decades agricultural communities have struggled to manage nutrient and soil loss, but growing public concern over water quality has led to renewed efforts to build innovative programs of watershed management.

The Boone River Watershed (BRW) initiative in north central Iowa is a large, multi-stakeholder effort to design a scalable system of adaptive watershed management that could be applied in other watersheds in the region. Program partners include environmental and agricultural organizations from public, private, and non-profit sectors. Beginning in 2004, these groups have worked towards a common agenda of improving environmental performance at field and basin scales while preserving and enhancing financial viability at farm scales. Partners' ongoing dedication to a watershed-wide, multi-scale monitoring program and to working with local farmers has contributed to their ability to target solutions, leverage funding, and engage new stakeholders. For example, since 2010 the BRW has received Mississippi River Basin Healthy Watersheds Initiative (MRBI) grants totaling $6.1

million and in 2013 the program received an additional $1 million when it was named a demonstration project for the Iowa Nutrient Reduction Strategy.

A key goal of the BRW initiative is to develop, test, and improve watershed programs to improve their subsequent implementation in other watersheds. Toward this end, partners commissioned a three-part science evaluation to measure biophysical and socioeconomic indicators of success, identify remaining barriers, and offer recommendations for future program outputs. Our team conducted a third-party evaluation of social dynamics in the BRW to provide insight on improving partner alignment and farmer engagement. Here we present findings and recommendations useful to other watershed improvement efforts, especially those focused on improving agricultural nutrient management.

Background

Iowa has been at the forefront of agricultural non-point source pollution (NPSP) problems for decades. As of April, 2012 there were 480 water bodies on the state's 303(d) impaired waters list (IDNR 2012) and agricultural NPSP in the form of excess bacteria, nutrients, and sediment contributes significantly to those impairments. The State of Iowa also supplies a large percentage of the excess nutrients that cause Gulf hypoxia (Alexander et al. 2008, David et al. 2010). Row-crop agricultural practices collectively are among the main drivers of water quality degradation in Iowa, in large part because agricultural land accounts for 12.4 million hectares (30.7 million acres) – or about 86% of the state's land cover (USDA 2011). Nutrients such as nitrogen and phosphorous are applied as fertilizer and lost through leaching, surface run-off, and erosion. An estimated 52% of the nitrogen and 25% of the phosphorous reaching the Gulf of Mexico is lost from corn and soybean systems located in the Mississippi River basin (Alexander et al. 2008).

Because agricultural NPSP poses a threat to environmental and human health, Iowa farmers and agribusiness organizations face pressure to demonstrate voluntary improvements in water and soil conservation. Complex economic, agronomic, and social factors, however, make it difficult for watershed practitioners to engage farmers in water quality outcomes (Napier et al. 1993; Baumgart-Getz et al. 2012; Reimer et al. 2012). To overcome barriers to farmer adoption of water quality management practices, government agencies employ cost-share and technical assistance to incentivize farmers to adopt practices aimed at soil and water conservation. These programs historically have been assessed according to the number of practices implemented rather than the cumulative effects of those practices, and have therefore been limited in their ability to demonstrate improvements to the natural resource base (Meals et al. 2010; Legge et al. 2013). Despite decades of extensive efforts and billions of dollars spent to implement best management practices (BMPs) on private lands, measureable progress toward natural resource objectives have been limited (Claassen and Ribaudo 2006; Reimer et al. 2012).

For water quality management programs to be effective – both in terms of costs and biophysical outcomes – research suggests field- and farm-level outputs must be coordinated with implementation, monitoring, and evaluation at watershed scales (Wortmann et al. 2008; Morton and Brown 2011; Rickenbach et al. 2011; Legge et al. 2013; Tomer et al. 2013). Although watershed boundaries do not correlate with socio-political boundaries (Atwell et al. 2009), managing according to ecological boundaries allows watershed practitioners to target resources to the most vulnerable parts of the landscape (Legge et al. 2013). Additionally, water quality monitoring data collected at the field, tileshed, sub-basin, and watershed scales allows practitioners to evaluate how NPSP behaves over multiple spatial and temporal scales. Coordinating field- and farm-level outreach with wider watershed goals helps stakeholder groups engage in water quality management at multiple social-ecological scales.

To link monitoring data with targeting and outreach efforts, partner organizations in the BRW are experimenting with adaptive management – an "iterative decision-making process that incorporates formulation of management objectives, actions designed to address those objectives, monitoring of results, and repeated adaptation of management until desired results are achieved," (Herrick et al. 2012, p. 105A). This form of strategic, experimental management is often utilized in complex social-ecological systems characterized by high levels of uncertainty (Pahl-Wostl et al. 2007), and is becoming common in integrative and coordinated resource management programs (Allen et al. 2010; Herrick et al. 2012).

As watershed programs in Iowa (and the Corn Belt region) shift towards an adaptive, targeted approach, they are also moving towards more diversified stakeholder collaborations (Morton and McGuire 2011; Comito et al. 2013). Watershed projects have begun to attract stakeholders from the business, non-profit, and public sectors and to gain success through collaborative management (Moore and Koontz 2003; Bidwell and Ryan 2006). Plummer (2009) argues that the merging of collaborative and adaptive natural resource management can lead to diverse social networks that "facilitate learning through feedback, emphasize social processes that encourage flexibility, and build capacity for adaptation." Within a multi-stakeholder watershed program such as the BRW initiative, public-private partnerships create more opportunity for watershed managers to target vital parts of the landscape, avoid overlapping or contradictory outputs, reach more farmers, and leverage new sources of funding (Morton and McGuire 2011; Hanleybrown et al. 2012). As the majority of multi-stakeholder watershed programs are still in their infancy, however, questions remain about how best to organize these initiatives (Plummer 2009).

The Boone River Watershed Program

The BRW program provides an example of an adaptive, multi-stakeholder watershed initiative. Located in central Iowa, the BRW is designated a HUC-8 watershed and contains 30 smaller, HUC-12 sub-basins (Blann 2008) (Figure 1). It spans 237,000 ha over six Iowa counties on the Des Moines Lobe (Blann 2008), a region of central Iowa known for rich glacial soils, gentle slopes, and high agricultural productivity. Nearly 99% of the watershed is privately owned and more than 90% of the land is in agricultural production (NRCS 2008). Corn, soybeans, hogs, and poultry are the primary agricultural enterprises in the area.

Prior to settlement, the BRW was poorly drained wetland with morainal soils and interconnected prairie potholes (Prior 1991). Today the hydrology is dramatically influenced by extensive tile drainage networks. Although artificial drainage supports crop production, tile networks also contribute heavily to surface water degradation (Kalita 2006; Alexander et al. 2008; David et al. 2010). Nutrients from manure, artificial fertilizers, and natural soil processes leach into tile lines and are delivered to surface waters. Additional nutrients and sediment are lost through erosion and runoff.

Because watersheds such as the BRW contribute to Iowa's water quality problems and ultimately to Gulf Hypoxia, they are the focus of growing local and national concern (Alexander et al. 2008, Blann 2008). The BRW is a tributary of the Des Moines River, which is the secondary source of drinking water for the city of Des Moines and surrounding areas. Nitrate levels in the Des Moines River watershed are of great local concern because the city installed an expensive nitrate removal system to cope with nutrient pollution in its source waters, including the Des Moines and Raccoon rivers.

In addition to local concerns about drinking water quality, Iowa faces national pressure to manage nutrient and sediment pollution. In response to the 2008 Gulf Hypoxia Action Plan (EPA 2008) to improve water quality in the Mississippi River, Iowa conducted a science assessment and developed a statewide strategy to cope with poor surface water quality. The Iowa Nutrient Reduction Strategy calls for a 41% reduction in nitrogen export and 29% reduction in phosphorous export from agricultural lands in the state (Iowa 2013). The strategy presents state-wide management scenarios that would help the state meet reduction goals, but as of now farmer compliance with the strategy is voluntary. Although Iowa has designated considerable funding to incentivize water and soil management practices outlined in the reduction strategy, the voluntary nature of the strategy has been controversial. Many organizations and individuals are pushing to regulate Iowa agriculture, while other groups fear that a regulatory system will be both costly and ineffective (ISU 2013).

To find voluntary solutions to water quality problems associated with agriculture, the Iowa Soybean Association (ISA), The Nature Conservancy (TNC), and local offices of government agencies began partnering in the BRW in 2004 to conduct assessments of water and stream bank quality. Other organizations, prominently Agriculture’s Clean Water Alliance (ACWA) and Des Moines Water Works (DMWW), joined the program in 2007 to help implement an extensive, three-tier water monitoring and evaluation program in the watershed. The partnership’s goals were to determine how agricultural practices influence water quality on watershed, sub-watershed, and field levels, and to develop and implement science-based solutions to water quality problems.

Additional organizations have joined the BRW partnership to work towards a common goal of maintaining agricultural production while protecting water quality and enhancing environmental performance. Partners have been able to leverage a number of federal and private grants to implement an adaptive co-management program in the BRW (Figure 2). Within a broad environmental resource-planning context, program leaders work with farmers to implement in- and edge-of-field practices such as, strip-till, cover crops, denitrifying bioreactors, and nutrient management (e.g., modifying nutrient source, rate, timing and placement).

In the spring of 2012, we were asked by ACWA and ISA to serve as third-party program evaluators with a focus on assessing multi-scale social dynamics of the program. Our evaluation was part of a three-part science assessment of biophysical and socioeconomic drivers within the BRW. To understand decision-making processes and stakeholder communication in the BRW we conducted and analyzed 33 semi-structured interviews with BRW stakeholders, including program partners, farmers, technical service providers, and agribusiness retailers. We selected respondents based on non-probability sampling methods, which provided us with a diverse range of perspectives on program management, outputs, and objectives (Neuman 2013). We triangulated primary interview data with formal analysis of BRW documents such as grant applications, progress reports, and outreach materials. We utilized a grounded theory methodology to answer the following research questions:

- What progress have partners made towards their stated outcomes?
- What are the remaining barriers to fulfilling program objectives?

- What recommendations do BRW stakeholders have for how to improve the program?
- What lessons can be learned from other successful watershed initiatives?

Our evaluation highlighted program successes, remaining gaps, and allowed for a prioritization in the context of recommendations presented to BRW organizational partners. All recommendations were informed by interview data, research conducted in other watersheds, and literature on organizational management.

Evaluation Findings and Recommendations

Here we report key findings and recommendations from the BRW program evaluation so that other watershed groups can potentially benefit. Findings are organized under three main lessons regarding the multi-scale monitoring and evaluation system, relationships among diverse stakeholders, and a transparent, backbone structure to streamline collaboration, planning, and evaluation.

Lesson One: A multi-scale monitoring and evaluation system is a foundation upon which diverse watershed stakeholders can base adaptive co-management.

The BRW water monitoring network and field-level data form the foundation for multi-scale adaptive management. To monitor nitrate, phosphorous, and cyanobacteria, partners collect bi-weekly grab samples and storm event samples from several sites along the main-stem of the Boone River, at the end of each HUC-12 tributary, and at the sub-basin level in Lyons Creek. They also work with farmers to monitor tile drains. At the program planning level, water monitoring data help partners understand the causes of water quality problems, target areas that contribute most heavily to nutrient loading, evaluate the efficacy of BMPs, and write and carry out management plans that link fields and farm systems to their immediate basin and then to the broader watershed. Partners cite evidence from the water monitoring network and watershed plans to attract additional private and public funding. For example, the first several years of water monitoring data in the BRW identified three HUC-12s with especially high nitrate levels. Partners used those data to leverage private and public funding to prepare watershed plans for the targeted HUC-12s. The watershed plans and ongoing monitoring have helped partners leverage additional funding to remain engaged in those watersheds. Over the past 4 years the BRW has received approximately $6.1 million in MRBI funding, $1 million from being selected as a demonstration watershed for the Iowa Nutrient Reduction Strategy, and a number of other private and public grants.

At the field level, farmer and agronomist respondents indicated that data from stalk nitrate sampling, tissue and soil testing, and bioreactor or tile-line samples allow them to tweak management plans to reduce nutrient and soil loss. Where applicable, bioreactor and tile-line data help farmers gauge their contribution to water quality problems and better manage nutrients. One farmer highlighted the importance of individualized data when he stated, "working with [ISA staff], that's given me a lot more insight than I would have had otherwise and it encourages me to keep doing what I'm doing. I think that if other farmers knew that their water was high in nitrates they might think, 'well, maybe I am part of the problem,' but most people don't know that." Several farmers in the BRW were unaware of the opportunity to conduct tile-line sampling; yet all respondents indicated they would be interested in implementing the practice as long as the data remain confidential and they trust the organization that collects and stores the information.

Given that a credible, multi-scale water quality monitoring and evaluation system provides the foundation for evaluation and learning, we recommend that efforts to assemble such systems be prioritized by watershed groups and funders. Furthermore, as a watershed is a social-ecological system, we recommend that a monitoring and evaluation network measure and use social and ecological data to target areas and improve outreach. The Social Indicators Planning and Evaluation System outlined by Genskow and Prokopy (2008) is an example of a social monitoring system that could be used to measure social dynamics in watersheds such as the BRW. Ecological and social monitoring should take place at field, tile-shed, sub-basin, and watershed scales to personalize data for all program participants and guide adaptive planning and outreach by program partners. If possible, baseline data should be collected in the first stages of program development. Watershed programs should also make an effort to provide interested farmers with environmental and agronomic data that can be help guide management decisions. For example, tile-line sampling provides farmers with information on how much nitrate they are losing from their fields. Personalized data should be presented by a trusted source and interpreted in ways that are meaningful to farmers.

Lesson Two: Strong partnerships and relationships between diverse stakeholders are vital to program success.

Partners working in the BRW recognize that both agricultural and environmental objectives require nutrients and sediment to stay in-field rather than moving into waterways. According to a respondent from the USDA Natural Resources Conservation Service, “The Iowa Soybean Association, Nature Conservancy, the Soil and Water Conservation District, and us – we’re all looking to reduce nitrogen… or to reduce all of the micronutrients and major nutrients in the water supply. And we just go about it in different ways. That's what is so nice, because each have their expertise." Because partners in the BRW have found common ground they have been able collectively to reach more farmers, implement monitoring at multiple scales, engage agronomists, leverage funding, and explore alternative, multifunctional management practices.

If watershed efforts are to succeed in the long-term, farmers and landowners must share the common vision of multi-beneficial agricultural systems that protect natural resources while providing food. While the adoption literature offers insight into farmer decision-making processes (Napier and Camboni 1993; Rogers 2010; Pannell et al. 2006; Knowler and Bradshaw 2007; Prokopy et al. 2008; Baumgart-Getz et al. 2012; McGuire et al. 2012; Reimer et al. 2012; Sharpley et al 2012), researchers and practitioners continue to struggle with how best to engage farmer stakeholders (Prokopy et al. 2008; Baumgart-Getz et al. 2012; McGuire et al. 2012; Reimer et al. 2012). The diffusion of innovations theory suggests a technology or idea is more likely to spread if local opinion leaders publicly support the innovation (Rogers 2010), and our data support this theoretical claim. Program partners in the BRW identified a handful of current or potential "farmer champions," who promote BMPs and help other farmers learn to manage new practices. The majority of farmer respondents spoke highly of these champions and there is evidence that certain practices are diffusing more rapidly because of their influence. Farmer respondents from the BRW were also more likely to try a new BMP if they had a trusting relationship with one or more program leaders. Farmers in the BRW named a handful of program staff with whom they have close relationships; these same individuals were particularly effective at engaging farmers to try a new practice.

Our recommendation was that the incorporation of additional organizations and businesses working in the area would strengthen the partnership. Effort should be placed on further relationship building. Stakeholders should work together to create additional opportunities to apply for or leverage funding, experiment with new ideas or BMPs, and build relationships with resistant farmers. Additionally, watershed partners should intentionally cultivate leadership among conservation-minded farmers with high social capital. Outreach and training for farmer leaders should be a strategic element of watershed program outputs.

Lesson Three: Multi-stakeholder watershed initiatives would benefit from a transparent, backbone structure to streamline collaboration and communication.

One of the primary gaps we identified in the BRW program was the lack of a coordinated communication system. As of now, intra-organizational communication is often dependent upon relationships between program leaders. Several respondents indicated they would like to re-form a backbone organization to ensure all groups maintain focus, create opportunities for brain-storming and creative problem solving, and help leverage additional funding. Attendees at a stakeholder meeting for BRW leaders expressed great interest in more regular meetings, as they were able to generate many ideas in a short time when given the opportunity to have an unhurried roundtable discussion.

We also identified a communication gap between program personnel and farmers. Although program partners have amassed data that indicate nitrate loading is clearly an agricultural problem in the BRW, no particular group has taken the responsibility to communicate the results of water monitoring data with farmers. Our findings suggest that many BRW farmers are unsure of the severity and/ or causes of nutrient and sediment pollution in their region; if these data were clearly communicated, they could be a source of motivation for farmers. One farmer respondent said: "[Brian] shared a little bit of [the BRW water monitoring data] with me. Yeah we're… he's finding that [nitrate] is getting in there. And the amount shocked me that I've seen from him. So we need to do better." Because water quality data have the potential to dispel misconceptions about the existence or severity of water quality issues, we recommended that partners make watershed-level data a key element of their outreach efforts. BRW program leaders are in the process of building a coordinated marketing campaign – a project we believe a backbone organization could oversee.

Based on identified gaps, we recommended that BRW partners would benefit from a coordinating entity. An independently staffed backbone organization would implement organizational processes to support strategic collaboration and facilitate the adaptive management process. The backbone organization would conduct tasks necessary to program success but which are not the responsibility of any one program partner. For example, the organization could coordinate stakeholder meetings; coordinate an outreach and marketing campaign to fill communication gaps with farmers; implement evaluation processes that address collective effort rather than outputs from certain organizations; and identify and engage additional partners to fill programmatic gaps. At the time of writing, BRW partners were excited by the idea of a backbone organization and exploring potential structures and funding sources. One model we recommended was the collective impact model, described by Kania and Kramer (2011).

Conclusion

For the past 10 years the Boone River watershed has been the focus of significant monitoring, planning, outreach, and funding efforts. Program partners and funders believe investments in the BRW will not only yield improvements to local water quality, but help refine a framework that can ultimately be transported to and used within other watersheds. Because nutrient loads respond slowly to changes in land management and use, there are still too few years of monitoring data to detect significant nutrient reductions at the watershed scale. However, partners have demonstrated progress towards short and mid-term outcomes, which may eventually lead to long-term goals for decreased nutrient loading in the BRW.

Mid-term indicators of success for the BRW program include the ability to leverage resources, engage farmers in program outputs, and use data to guide adaptive decision making at multiple scales. BRW partners have shown how multi-sector collaboration between diverse organizations can strengthen outputs to meet each of those goals. For example, leaders from certain organizations are able to reach out to farmers through outlets that are less available to their partners, thereby increasing the likelihood of widespread farmer engagement. Partners have also demonstrated how water monitoring data can be used to effectively target resources to key parts of the landscape, leverage grant funding, and shift farmers' perceptions of water quality and water quality management practices. Progress in the BRW indicates that other groups may benefit from building diverse partnerships, investing in water quality monitoring, engaging in watershed planning, and fostering strong relationships with farmers.

While BRW partners are on track to meet a number of short- and mid-term goals, we identified some programmatic gaps that could serve as barriers to meeting long-term objectives for water quality improvement. Many of the identified gaps could be filled by an independent backbone organization that coordinates partner outputs, conducts social monitoring, and organizes multiple scales of communication and outreach strategies. While more thought, effort, and time is needed to understand how to best organize a backbone structure for a large agricultural watershed program, the collective impact model for social change offers a compelling framework for experimentation (Kania and Kramer 2011).

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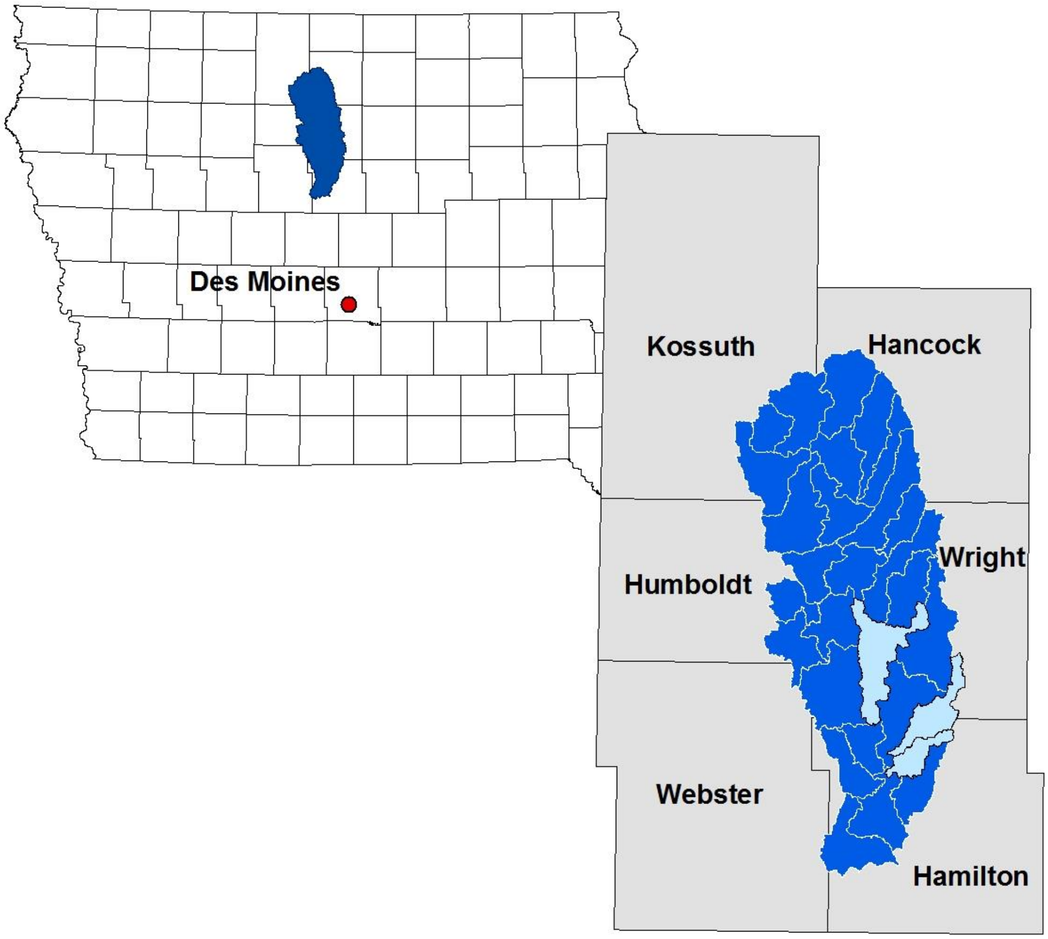

Figure 1. *Map of the Boone River watershed in Iowa, USA. The BRW is a HUC-8 watershed containing 30 HUC-12 sub-basins. Lower Eagle, Buck, and Lyons Creeks are highlighted in light blue.*

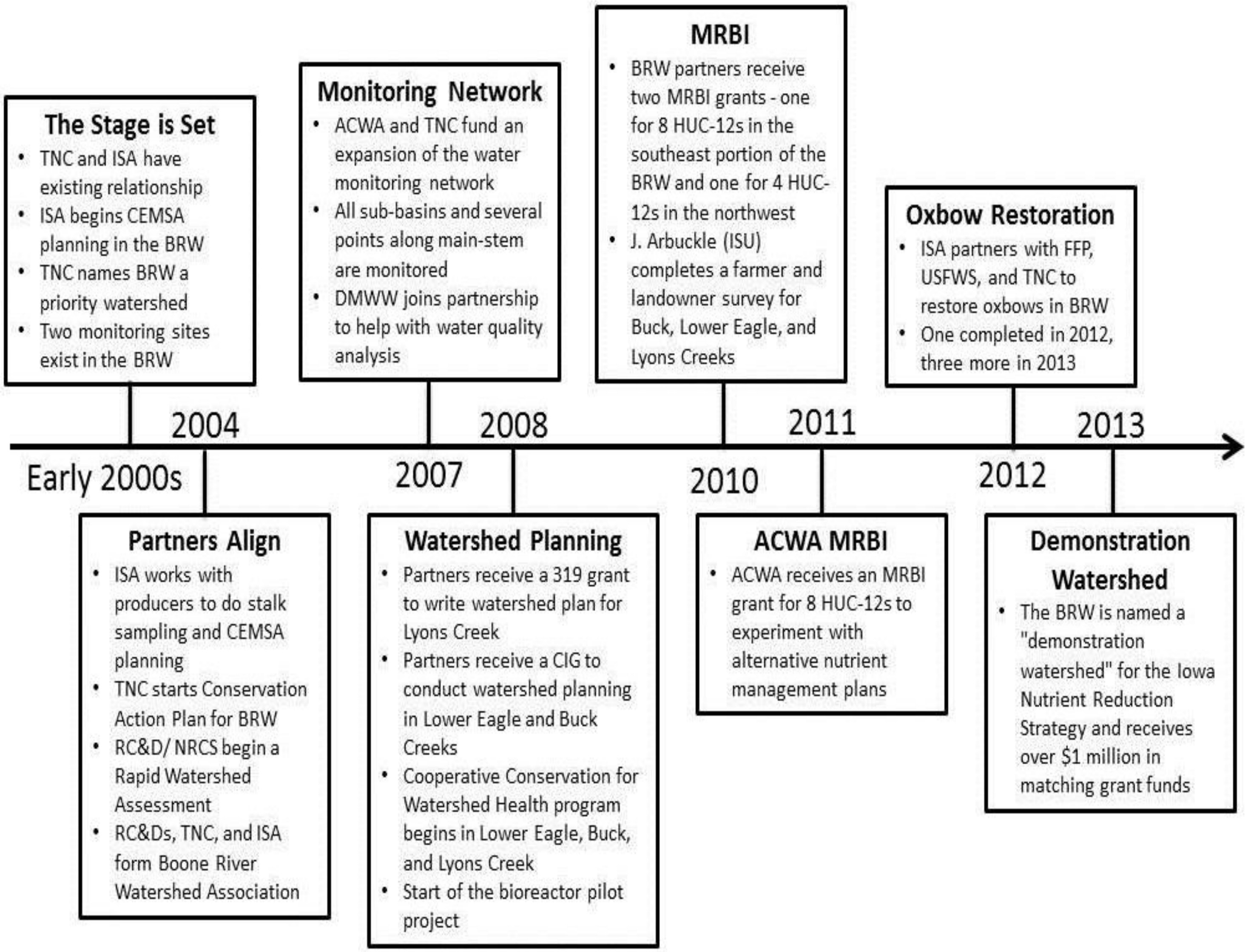

***Figure 2**: Timeline of major events associated with the Boone River watershed program*

CHAPTER 3

WORKING BEYOND SCALE CHALLENGES: PRIVATE-PUBLIC PARTNERSHIPS AS A STRATEGY FOR RESILIENT WATERSHED PROGRAMMING

A paper to be submitted for publication to *Ecology and Society*

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Abstract

In recognition that Iowa agriculture must maintain long-term production of food, fiber, clean water, healthy soil, and robust rural economies, Iowa recently devised a nutrient reduction strategy to set objectives for water quality improvements. To demonstrate how watershed programs and farmers can reduce nutrient and sediment pollution in Iowa waters, the Iowa Water Quality Initiative selected the Boone River Watershed (BRW) Nutrient Management Initiative as one of eight demonstration projects. For over a decade, diverse public, private, and non-profit partner organizations have been working in the BRW to engage farmers in water quality management efforts. To evaluate social dynamics in the BRW and provide partners with actionable recommendations, we conducted and analyzed semi-structured interviews with 33 program leaders, farmers, and local agronomists. We triangulated primary interview data with formal analysis of BRW documents such as grant applications, progress reports, and outreach materials. Our evaluation suggests that while multi-stakeholder collaboration has enabled partners to overcome many of the traditional barriers to watershed programming, scale mismatches caused by external socioeconomic and ecological forces still present substantial obstacles to programmatic resilience. Public funding restrictions and timeframes often cause interruptions to adaptive management of water quality monitoring and farmer engagement. We present our findings within a resilience

framework to demonstrate how multi-stakeholder collaboration can help sustain adaptive watershed programs to improve socio-ecological function in agricultural watersheds such as the BRW.

Keywords: watershed management; adaptive co-management; resilience; Iowa; agriculture; non-point source pollution; social-ecological solutions; evaluation

Introduction

Over the past 150 years the Iowa landscape has been transformed from tallgrass prairie, wetlands, and savanna to predominantly row-crop agriculture (Prior 1991). Agriculture now accounts for over 85% of the state's land cover (USDA 2014). Agricultural expansion has been driven by the demand for feed crops, exports, and more recently biofuel production (Secchi et al. 2011), which in turn influence markets, policy, and farmer decision-making (Atwell et al. 2009). On the Des Moines Lobe – a geological region of north central Iowa known for gentle slopes and rich, heavy soils (Prior 1991) – row-crop agriculture has been accompanied by the installation of extensive tile-drainage networks that alter regional hydrology (Alexander et al. 2008, David et al. 2010).

Although central Iowa corn yields are now exceptionally high, averaging over 11,422 kg/ ha (170 bu/ac) (ISU Extension 2014), this productivity comes at a cost to water quality, biodiversity, and soil health (Strivastava et al. 1996, David et al. 2010). The public has become particularly concerned with water quality, as surface waters have been severely degraded by row-crop agricultural practices. Nutrients, sediment, pesticides, and bacteria from agricultural fields enter Midwestern surface waters via runoff or after leaching into underground tile lines (Booth and Campbell 2007, David et al. 2010). These pollutants are of great concern to local and downstream users. Because agricultural pollutants such as nitrogen pose a risk to human health, Des Moines Water Works installed a $3.7 million Nitrate Removal Facility in 1991. This facility costs about $7,000 per day to run and is utilized when nitrate loads exceed the safe drinking water standard (DMWW 2013). Agricultural pollutants from the Upper Mississippi basin also account for a disproportionate amount of the nitrogen and phosphorous leading to hypoxia in the Gulf of Mexico (Alexander et al. 2008, David et al. 2010). In Iowa, an estimated 92% of total nitrogen and 80% of total phosphorous entering surface waters originate from non-point sources such as agricultural fields (Iowa 2013).

While water pollution associated with agriculture has sparked local and national attention, agricultural and economic policies in the region continue to primarily incentivize farming practices geared towards maximizing corn and soybean yield rather than managing for multiple system benefits. Government agencies have worked for decades to advance ecological function by helping farmers implement soil and water management practices. But despite the billions of dollars spent on cost-share incentives and technical support, government programs have failed to demonstrate marked progress toward natural resource objectives (Claassen and Ribaudo 2006; Reimer et al. 2012).

In response to mounting public pressure to solve quality problems, the State of Iowa recently adopted a nutrient reduction strategy aimed at reducing both point- and non-point-source pollution (Iowa 2013). The strategy calls for a 41% decrease in nitrogen and 29% decrease in phosphorous from non-point agricultural sources. To meet these reduction goals, farmers across Iowa are being incentivized to voluntarily adopt a mix of targeted in- and edge-of-field management practices as well as experiment with new land uses and crop rotations (Lawrence 2013). The State of Iowa has also targeted a suite of "demonstration watersheds," where stakeholders are already involved in water quality management projects. These demonstration watersheds serve both as a mechanism for farmers to view well-vetted nutrient reduction practices as well as an experimental site for emerging technologies (IDNR 2013). One of the demonstration watersheds is the Boone River watershed (BRW), where diverse public, private, and non-profit organizations have been involved for over a decade.

The BRW is representative of many Corn Belt watersheds, particularly those located on the Des Moines Lobe. Nearly 99% of the BRW is privately owned and more than 90% of the land is in agricultural production (NRCS 2008). Row-crop production of corn and soybeans is the dominant land use and up to 60% of the watershed contains subsurface tile drainage (NRCS 2008). As is typical of such watersheds (Alexander et al. 2008), agricultural practices in the BRW are the primary contributors to nutrient loading in local and downstream surface waters. Nitrate is the principal non-point source pollutant in the BRW—for several months each spring nitrate concentrations in the Boone River and most of its tributaries remain well over the drinking water standard of 10 ppm (ACWA 2011).

Since 2004, agricultural and environmental organizations from the private, public, and non-profit sectors have collaborated to build an adaptive water quality management program in the BRW. Agriculture's Clean Water Alliance (ACWA), Iowa Soybean Association (ISA), the USDA Natural Resources Conservation Service (NRCS), and The Nature Conservancy (TNC) play prominent roles in the overall BRW program, but over a dozen organizations are involved in specific projects and/ or as funders. Collectively, these organizations seek to understand how nutrients can be managed at multiple spatial and temporal scales and to engage farmers in water quality management objectives.

Through stakeholder interviews and document analysis, we sought to understand the internal and external social-ecological force affecting BRW program progress. We used the framework of resilience theory to interpret our findings. Resilience theory emerged as a frame for understanding how complex ecological systems respond to disturbance has since been expanded and to explore issues of management in complex social-ecological systems. Indeed, Walker et al. (2006) state that “the notion of resilience is growing in importance as a concept for understanding, managing, and governing complex linked systems of people and nature.” Of particular interest to our study are the concepts of adaptive co-management, programmatic resilience, and scale challenges, which emerged from the resilience literature.

Adaptive co-management is an emerging approach to managing complex social-ecological systems and is “depicted as a governance system involving heterogeneous actors and cross-scale interactions” (Plummer 2009). This new approach represents a marriage between co-management (Moore and Koontz 2003, Bidwell and Ryan 2006) and adaptive management (Pahl-Wostl et al. 2007, Allen et al. 2011, Herrick et al. 2012), which are increasingly popular methods of coping with uncertainty and complexity in managed social-ecological systems. Barriers to management efforts in such systems are frequently defined as scale challenges, defined by Cash et al. (2006) “as a situation in which the current combination of cross-scale and cross-level interactions threatens to undermine the resilience of a human-environment system,” where a scale is “the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon” and levels are “the units of analysis that are located at different positions on a scale” (Cash et al. 2006).

Here we explore scale challenges that affect the resilience of adaptive co-management efforts in the BRW. In so doing, we aim to illustrate remaining barriers to program implementation and identify possible solutions. We propose as well to provide insight for other Iowa watershed programs and to identify levers for change within social-ecological systems closely related to the BRW.

Methods

Study area

The Boone River Watershed (BRW) is a HUC-8 watershed in Central Iowa containing 30 smaller, HUC-12 sub-basins (NRCS 2008). The BRW spans 237,000 ha over six Iowa counties in the Des Moines Lobe (Blann 2008), a landform in north central Iowa characterized by rich glacial soils, gentle slopes, and poor drainage. This landscape was shaped by the most recent glacial advance into Iowa, which occurred 12,000 – 14,000 years ago (Prior 1991). Prior to settlement, the BRW was a poorly drained wetland complex with morainal soils and interconnected prairie potholes (Prior 1991). Over the past 100 years the majority of the BRW has been dramatically altered to accommodate row crop agriculture.

Boone River Watershed program

In 2004, TNC named the BRW a Mississippi River Priority Watershed because of high ecological and economic significance. At this time, ISA was already working with BRW farmers to conduct stalk-nitrate sampling and agreed to partner with TNC to create a Conservation Action Plan for the watershed (Table 1). To better understand water quality issues and nutrient movement in the BRW, ISA and TNC also partnered with local offices of government agencies to conduct a stream-bank assessment for the entire BRW (NRCS 2008).

In 2007, with support from ACWA, Des Moines Water Works, ISA, and TNC, BRW partners implemented a multi-scale water monitoring and evaluation network.

The BRW water monitoring network collects bi-weekly water quality samples at multiple locations along the main reach of the Boone River and at the base of each of the 30 HUC-12 tributaries. Partners also collect storm event samples, installed several real-time water quality sensors, and worked with farmers to collect field-scale data such as stalk-nitrate samples. Thus far, partners have used monitoring data to assess baseline conditions and target areas of the watershed with high nutrient loss. Partner organizations also used these data to apply for funding to write watershed plans for three HUC-12 sub-basins in the BRW. The watershed plans and the monitoring data have brought new opportunities to fund projects and engage farmers with environmental management planning and best management practices (BMPs).

Through monitoring, planning, and outreach efforts the BRW program has gained the momentum to attract significant resources. For example, between 2010 and 2011 the program received three Mississippi River Basin Healthy Watersheds Initiative (MRBI) grants totaling over $6.1 million. The grants allowed partners to hire a coordinator to conduct outreach and to provide cost-share incentives for farmers to try in-field BMPs such as strip-till, cover crops, nutrient management plans, and edge-of-field BMPs such as denitrifying bioreactors. Though they do not provide in-field benefits, bioreactors provide downstream benefits by filtering nitrate from tile-line water before it enters the stream.

In the spring of 2012, we were asked by two BRW program partners, ACWA and ISA, to serve as third-party program evaluators with a focus on assessing multi-scale social dynamics of the program. Our evaluation was part of a three-pronged science assessment that also included research on hydrological processes in one of the sub-watersheds and an evaluation of BRW water quality data (Chris Jones, ISA, personal communication).

Data Collection

We selected a case study approach to investigate the social-ecological system bounded by the BRW. A case study is, "an in-depth, multifaceted investigation, using qualitative research methods, of a single social phenomenon" (Orum et al. 1991, p.2). A case can be a simple or complex system, but must be "one among many" similar systems (Stake, 1995). A case study permits in-depth analysis of relationships, knowledge and value systems, and decision-making processes among the pertinent stakeholders involved in a program. As with any method, a case study has limitations. Qualitative case studies are not necessarily generalizable to other populations or programs (Floress et al. 2011). We did not find this limitation problematic because our goal was to investigate a specific, complex system rather than to make claims about watershed programs in general. Our methods allowed us to fulfill our primary goal: to conduct a utilization-focused evaluation (Patton 2008) and gain a systems perspective on the BRW social-ecological system. Because the BRW is similar to other watershed in the Des Moines Lobe, our findings may be of interest to other adaptive management programs in the area.

To become familiar with the many projects and stakeholder groups in the BRW, we thoroughly reviewed program documents such as progress reports, partner websites, water quality data, and grant proposals. We used these documents to construct a comprehensive program logic model (UW Extension 2014), timeline, and influence diagram outlining how separate projects, grants, and organizations have been combined to advance intended program outcomes. These documents enabled us to visualize program continuity or gaps, given that the BRW program is composed of many related, short-term projects and that not all partners are involved with all program elements. To deepen our understanding of the diversity of stakeholder perspectives on the program, we conducted interviews and formal meetings with program leaders, local agronomists, and BRW farmers. Interviews provided essential insights on communication strategies and decision-making processes at various levels within the BRW program.

From August 2012 through May 2013, we conducted in-depth, semi-structured interviews with three types of BRW stakeholders: program leaders (n=15), agronomists (n=4), and farmers (n=14). Program leaders – defined as individuals who have been heavily involved in program planning and/ or implementation – from public, private, and non-profit organizations were questioned regarding their relationships with other organizations involved in the BRW, program outputs and objectives, successful elements of the BRW initiative, and barriers to program implementation. Respondents were identified through snowball sampling, a process whereby respondents are located through recommendations made by other respondents (Esterburg 2002). Because we were contracted by ACWA and ISA to conduct a third-party evaluation, we were already acquainted with several program leaders from those organizations. ACWA and ISA respondents were able to direct us to program leaders from other stakeholder groups, who then recommended additional interviewees. This nonprobability sampling method (Babbie 2012) enabled us to meet with all but 2-3 program leaders.

Following a grounded theory approach, we conducted preliminary analysis of program leader interviews to inform the questions we asked agronomists and farmers

(Strauss and Corbin 1990, Esterberg 2002). Agronomist respondents were identified through program leader contacts and represent all agronomists who had been involved in BRW program outputs up to that time. We recruited farmer respondents through ISA, NRCS, and local agronomist contacts. Our objective was to represent a spectrum of perspectives by interviewing farmers with a range of experience with BRW program outputs; thus, we purposively sampled to include a diversity of farmer experiential perspectives (Babbie 2012). ISA and NRCS staff recommended farmers who were heavily involved, newly involved, or minimally involved in BRW program outputs. Agronomists provided further contacts with farmers who were not involved with the program. We conducted interviews until we reached saturation, or no longer felt we were receiving new information from later interviews (Neuman 2003).

Stakeholder interviews followed a semi-structured format, which allowed us to probe topics relevant to our objectives as they arose while also maintaining some continuity across respondents (Babbie 2012). Program leader interviews were based on the program logic model built through our analysis of program documents, allowing verification of our understanding of program outputs and goals, assess progress toward stated outcomes, and identify barriers. On average, program leader interviews lasted 58 minutes (range: 43 – 96 minutes). We focused our interviews with farmers and agronomists on their knowledge and engagement with BRW program objectives, level of interaction and trust for program partners, and perspectives on program outputs. We placed particular emphasis on their knowledge or use of in- and edge-of-field BMPs (Table 2) and potential barriers to adopting new practices. On average, farmer interviews lasted 60 minutes (range: 38 – 97 minutes) and agronomist interviews lasted 59 minutes (range: 47 – 75 minutes).

Data Analysis

We used a grounded theory approach to inform interview protocols and data analysis (Strauss and Corbin 1990, Esterberg 2002). That is, findings, recommendations, and theoretical insights were based on data rather than hypothesis tests developed from existing theory (Strauss and Corbin 1990, Charmaz 2006). This inductive process was informed by an awareness of approaches to conservation program evaluation and watershed management, specifically Napier (1993), Taylor-Powell (1996), Patton (2008), Prokopy et al. (2008) Baumgart-Getz (2012), Reimer (2012), the USDA National Institute for Food and Agriculture Conservation Effects Assessment Project reports, diffusion of innovations theory (Rogers 2010), and others. Interviews were transcribed, coded, and analyzed using NVivo 10 software (QSR 2012). Data analysis was an iterative process that occurred parallel to data collection.

During initial coding, the first author assigned sections of transcribed interviews to existing nodes or created new nodes as ideas emerged. Existing codes were "received" from interview questions and were further informed by awareness of the watershed management literature and the diffusion of innovations theory (Strauss and Corbin 1990, Rogers 2010, Reimer et al. 2011). Different coding schemes were used for program personnel, agronomists, and farmers to explore questions pertinent to each group.

As themes emerged we began to gain a systems perspective on the BRW program. To further explore relationships between themes the first author carried out axial coding, a process whereby themes are grouped or re-grouped according to, "the conditions or situations in which phenomenon occurs; the actions or interactions of the people in response to what is happening in the situations; and, the consequences or results of the action taken or inaction" (Walker and Myrick 2006). Through axial coding we identified the major systems components and utilized matrix coding queries, text searches, and narrative analysis to explore how these components influence each other. The first author coded data according to programmatic, spatial, and temporal scales of influence and built a complex systems model to conceptualize how systems components connect across those scales (Cumming et al. 2006, Knoot et al. 2010). We used this model to explore which themes connected most strongly to program implementation and progress. We grouped themes according to categories and scale of influence to build the simplified systems model presented in this paper. To ensure rigor and validity in the data analysis process, the second author read approximately one half of the interviews and all authors participated in code development and review.

Results

Respondent Characteristics

We conducted 31 interviews with 33 BRW stakeholders. Two of our program leaders and two of our farmer respondents participated in interviews simultaneously. Of our 14 partner respondents, nine were involved with a private organization, four with a public agency, and one with a non-profit. At the time of the interviews, partner respondents had been involved in the BRW an average of 7.3 years, the median time of involvement was 5.5 years. Of the four agronomist respondents, two were associated with ACWA and two were not. All agronomist respondents had been involved with the BRW program, although to varying extents.

The fourteen farm operators we interviewed were all men. They ranged in age from their mid-forties to their early-eighties and had been farming an average of 29 years (range: 3 – 55 years). They farmed an average of 680 ha (range: 49 – 1,619 ha) (1,680 ac, range: 120 – 4,000 ac). Of that, they owned an average of 297 ha (range: 0 – 1,619 ha) (734 ac, range: 0 – 4,000 ac) and rented an average of 383 ha (range: 49 – 1,447 ha) (946 acres, range: 120 – 3,600ac). Most farmers rented or owned land in conjunction with family and all had grown up on a farm. All respondents grew corn and soybeans, four had livestock or hogs, and one custom farms for an organic operation. Several respondents said they used to have livestock or indicated they were moving towards more continuous corn acres.

Systems model

To illustrate how partnerships affected programmatic resilience, we built a system model to represent the BRW program based on themes that emerged from stakeholder interviews (Figure 2). Our model is organized according to three programmatic scales derived from by our program logic model, which was vetted by program staff: 1) intended objectives, 2) program outputs, and 3) contextual influences. The BRW system model is composed of themes and sub-themes that were identified through axial coding. The "Detectable Water Quality Improvement" and "Farmer Engagement" themes are the primary "Intended Objectives" of the BRW program expressed both in the program literature and during stakeholder interviews (Table 3). These themes form the base of the system model (Figure 2). Because the majority of the BRW is privately owned, BRW partners must be able to engage farmers to manage the landscape for water quality. We therefore consider "Farmer

Engagement" a vital intermediary objective that will theoretically lead to "Detectable Water Quality Improvement."

Themes and sub-themes at the intermediate "Program Outputs" level also emerged from interviews and program literature (Figure 2). Program leaders employ "Adaptive Management" strategies and draw on "Partner Alignment" to positively influence farmer engagement and track water quality improvement (Table 3). Themes at the upper "Context" level include factors that affect program outputs, but over which the BRW partners had limited or no control (Figure 2; Table 3). Because "Funding Structures" and correlated sub-themes were so strongly emphasized during program leader interviews, we focus the remainder of the paper on these themes.

Progress Toward Detectable Water Quality Improvement

To measure biophysical indicators of watershed health and improvement, partners have installed an extensive three-tier water monitoring network. They also work with farmers to collect field-scale agronomic and water quality data. Thus far, water quality and agronomic data have enabled partners to target areas of greatest conservation value, attract funding, write watershed plans, and inform outreach efforts. Because water quality responds slowly to land use change, however, biophysical data are currently of limited evaluative use. Funding restrictions further complicate evaluation efforts by restricting baseline data collection.

BRW stakeholders began monitoring watershed health in 2004, when ISA, TNC, and local government agencies partnered to conduct the Boone River Rapid Watershed Assessment (NRCS 2008) and formulate a Conservation Action Plan (Blann 2008). With monetary support from AWCA and TNC, partners installed a water quality monitoring network in 2007. Partners monitor nitrate concentrations and other indicators of water quality at several locations along the main stretch of the Boone River and at the base of each of its 30 HUC-12 tributaries. The BRW monitoring network therefore provides data at a much finer and more detailed level than are typically measured through the state-run water monitoring programs. Though costly, this element of the BRW program initially enabled partners to assess watershed conditions and guide conversations about management outputs and objectives. One program leader described the decision to implement a water quality monitoring network in the BRW:

> *"At that time, there was one ambient site in Webster City for the entire 580,000 acres. So as we started having these discussions up there… 'What's the water quality like? What are the issues? We know there's poor water, but we don't know what we're working with.' So, that was always a challenge, how do you address watershed issues if you don't even know what the data is about?"*

After expanding the monitoring network partners were able to target specific HUC-12s with high nitrate concentrations. Based on these data, partners applied for and received an Iowa Department of Natural Resources/ Iowa Department of Agriculture and Land Stewardship (IDNR/ IDALS) Planning and Development grant to write the Lyon's Creek Watershed Plan. As part of their work in Lyons Creek, program leaders installed a paired watershed experiment with funding from TNC and technical support from government agency and Iowa State University personnel. They work with farmers in two sub-basins in the Lyon's Creek watershed to implement best management practices and collect water quality data (bi-weekly grab samples and storm event samples) as well as stalk nitrate samples (Lyons Creek Watershed Plan 2012). Program staff compare data from the treatment sub-basins to data from a third, control basin to gauge how management practices affect water quality at a finer watershed level. Partner respondents highlighted the importance of this experiment, which allows them to better understand how nutrients move over finer spatial and faster temporal scales. When asked whether the paired watershed experiment will provide faster evaluative feedback, one program leader explained,

> *"We're still kind of calibrating and haven't really got the level of [practice] implementation. Because even in a paired situation you're going to need a fairly dramatic change before it's going to affect the water [within] a small amount of time. But yeah, I definitely think that the micro-watershed… drainage district, or smaller tile-shed scale is absolutely where we need to be implementing and monitoring practices to determine their effectiveness. If it's absolutely the right scale and approach."*

In addition to the funding for Lyons Creek, partners received a USDA Conservation Innovation Grant to write plans for two additional HUC-12s – Buck and Lower Eagle Creeks – and to work with farmers to implement farm-scale environmental management plans. The watershed plans describe the current state of water quality, set nutrient reduction goals, and estimate the number and type of in- and edge-of-field practices required to meet water quality objectives. Partners credit the monitoring network for the ability to access public funding and move forward with watershed planning and project implementation. One program leader explained,

> *"For the [USDA NRCS Conservation Innovation] grant, even though it's very much about working with farmers in specific watersheds, one of the reasons those watersheds were identified is because of the water monitoring data. It's also the continual water monitoring that we're using as our match to meet the federal dollars."*

To build on progress from watershed planning efforts, BRW partners applied for and received three different MRBI grants in 2010 and 2011. The MRBI is a USDA program that provides additional cost-share funding for farmers to adopt in-field and edge-of-field water quality management practices (Table 3). One of the MRBI practices available to farmers is tile-line sampling, whereby farmers can work with organizations such as ISA to monitor nitrate and other pollutants leaving their fields via tile outlets. For farmers who are interested, program leaders compare agronomic data to tile-line and/ or bioreactor data to help them measure and manage nutrient loss. Of our 14 farmer respondents, four have been able to use this feedback to conduct adaptive management within their own operation, three plan to use tile-line or bioreactor data more extensively but drought has so far been an obstacle, and three had not heard of the opportunity to conduct tile-line sampling but were “very” interested. When asked about his bioreactor, one farmer stated,

> *"One of the interesting things about the bioreactor is they test the nitrogen coming in and they test it going out. I guess I’m more concerned with the water coming in because it’s coming out of a field that’s been no-till for 7 to 8 years and then cover crop. I’m interested in how much nitrogen we’re retaining in that field. Because look at all the fields around. You can’t build a bioreactor for all these fields… I’m more interested in the practices that hold the nitrogen in there so you don’t need a bioreactor."*

Although personalized water quality and agronomic data are intended to help farmers evaluate field-level improvements, this process was complicated by dry weather conditions in 2011 and 2012. Many farmers who recently started monitoring field-level water quality had not seen many results because there was no water to monitor. Program leaders explained how weather related issues are just one of the complicating factors involved in any level of water quality evaluation. They explained that the larger a watershed is in size, the longer it takes for water quality to respond to land-use change and the more factors they have to take into account. Water quality data eventually will be used to evaluate how in- field and edge-of-field management practices influence nutrient concentrations at the HUC-12 and HUC-8 scales, but this process requires many years of data to account for system complexity. As one program leader described,

> *"Trying to do stuff on a short time scale you really need very expensive, intensive monitoring to factor out all the other things that come into play. If you've got to measure ... precipitation, soil temperatures, rotations, all that kind of stuff all explains part of it so you have to really take all that into account, which I wouldn't say we're set up exactly to do that yet. Ours is more to target, to guide, and eventually we'd like to see some results and there's ways to do it but… we're not set up to do it that fast."*

Funding restrictions also add complexity to water quality evaluation efforts in the BRW. For example, partners were not able to collect baseline data from tile-lines before farmers began to implement MRBI management practices. Program leaders said it would have been ideal to collect at least 2 years of data before farmers began using cover crops and strip-till. Because the funding to institute edge-of-field monitoring was part of a package that also included in-field practices, MRBI farmers implemented new management practices in the same year they began monitoring; separating the impact of these practices from annual weather variability is impossible in the short term. Several partner respondents identified the gap in baseline data – caused by both funding restrictions and drought conditions – as a major barrier to understand if the foundational objective has been achieved. They expressed frustration at external factors that inhibited data collection. When asked what type of change they could detect from tile-line monitoring, one respondent stated,

> *"NRCS came and interviewed myself and another coworker on edge-of-field monitoring that's being conducted as part of MRBI. They asked us the same question. We're like, well, we're 2 or 3 years in, you didn't let us collect any baseline data so I'm not sure if we're seeing an impact. And it's going to take time and that's a challenge."*

Although partners do not yet have enough years of data to detect nitrate reductions at the HUC-12 or HUC-8 scale, the monitoring and evaluation network in the BRW has been foundational to adaptive, field- and farm-scale elements of the program. All program leaders expressed a strong belief that BRW monitoring data have enabled them to target vulnerable parts of the landscape and track change at the sub-basin level or smaller. Additionally, these data have been a key leverage point to secure funding for watershed plans and engage farmers to implement and further monitor farm-scale water quality management. Indeed, it is broadly recognized by BRW stakeholders that "farmer engagement" provides an indicator of success that can provide more immediate feedback on landscape-level change and more directly influence adaptive program management.

Engaging Farmer Stakeholders in Water Quality Management

Program leaders recognize they cannot achieve water quality objectives without widespread, long-term farmer adoption of water quality management practices. Prior to our evaluation, however, they had limited feedback to gauge progress towards this vital objective. During our evaluation we used farmer interviews to explore their views on water quality, knowledge of program objectives, relationships with program partners, and level of engagement with water quality management practices. We identified four elements that correlated strongly with the theme "farmer engagement": acceptability of cost-share programs and practices, values and beliefs about water quality, relationships with program leaders, and farmer leadership.

Government-funded cost-share programs are a common method of incentivizing farmers to try a new management practice (Table 1). To become involved with a cost-share program such as the Environmental Quality Incentives Program (EQIP), Conservation Reserve Program (CRP), or Conservation Stewardship Program (CSP), farmers usually contact the NRCS office to express interest and ask a field agent to conduct a site assessment. If the farmer is eligible for a program they develop a management plan with the NRCS staff and sign a contract saying they will use the BMP(s) for a specified number of years. Farmers in all BRW HUC-12s have access to standard cost-share funding through EQIP, CRP, or CSP. Since 2010, farmers in a dozen of the 30 HUC-12s in the Boone have had access to expanded cost-share payments through the MRBI.

Although many BRW farmers have taken advantage of recent MRBI cost-share opportunities, program leaders expressed fear farmers will revert back to prior management strategies when payment periods end. They noted that if a farmer does not see measureable benefits or deems a practice too expensive to implement without cost-share, s/he is more likely to discontinue use after payments cease. Several farmer respondents confirmed this belief and stated that continued practice implementation was contingent on visible benefits. Farmer respondents differed, however, on whether they cared about quantifiable economic benefits or whether it was enough to see a difference in soil quality, for example. One respondent who had just talked about how much he enjoyed his cover crops went on to say,

> *"Now the question becomes would I continue to do cover crops if I didn't get paid to do it? I don't have enough data to say yes or no on that one. Because basically we haven't had normal years. We've had two kind of dry years in a row… I've got two more years in the program so I'm going to see what happens. Plus we've got three more years on the one up north… I mean if we can justify cutting our nitrogen by 10% it would definitely pay for the cover crops."*

Although almost all farmer respondents stated the belief that economic and environmental objectives are compatible, many farmers viewed NRCS practice standards as incompatible with their equipment, too expensive, or too inflexible. Among those farmers who were not involved with the NRCS – and even among some who are – practice standards and associated paperwork were commonly cited barriers to trying a new practice. One farmer who has grassed waterways (Table 2) but is not involved with a cost-share program explained,

> *"And that's why we never have done [a grassed waterway] with a cost-share or with the NRCS, because the restrictions on it are usually too big. You can't spray it or mow it when you want to; when you think it's right. You can't necessarily put down what you think is correct as far as crops and ... sometimes they way over-engineer them for what they need to be."*

Although cost-share programs such as the MRBI have been an effective tool to incentivize some farmers to try new practices, our data suggest that they may repel or exclude others. One farmer, for example, said he had been interested in trying cover crops and a bioreactor but could not sign up for the MRBI program because he was unwilling to implement a nutrient management plan (CPS 590). Although he was the only farmer to express serious concern about the nutrient management standard, agronomist respondents said they expected it would be difficult to convince farmers to change the amount of timing or their nitrate applications. Both farmer and agronomist respondents expressed support for the revised MRBI nutrient management standard, in which they could still apply fall-nitrogen as long as a nitrogen-inhibitor (Table 2) was used to potentially reduce the risk of leaching.

Land-tenure dynamics are an additional barrier to farmer engagement with cost-share programs. Even among those farmers who are heavily engaged with BRW program outputs and goals, "the landlord" and "rent prices" were commonly cited barriers to implementing management practices on rented ground. Furthermore, farmers articulated a wide range of barriers related to "the landlord." Some farmers simply wanted to ensure they could manage a practice well before approaching the landlord with a new idea, while others were afraid the landlord would raise rent or demand a cut of the cost-share payment. Still others thought their landlord was too old-fashioned to accept a new practice. One farmer respondent stated,

> *"The landlord is probably the biggest barrier to most everything… especially the older landlords. 'It's always been done this way' is a big thing with them."*

Given that our farmer respondents owned less than half of the ground they farm and that over 60% of Iowa farmland is now rented (ISU 2013), barriers such as the ones listed above pose a major obstacle to widespread implementation of water quality management. Because of these barriers, program leaders provide alternative options for farmers who are interested in trying a practice. For example, by securing flexible funding, TNC has been able to help a small number of farmers try in-field management practices without having to sign an NRCS contract.

For those farmers who are involved with the MRBI, partners aim to provide them with the data and technical support needed to foster long-term practice adoption. To encourage long-term farmer engagement, program leaders believe they must first build credibility and relationships with farmers. Program partners such as ISA and TNC began building relationships in the BRW when they partnered with local government agencies to conduct the Rapid Watershed Assessment in 2004. Upon receiving watershed planning support, they also formed farmer advisory committees to receive local input on the plans. One program leader described this process,

> *"We worked really hard to make sure that we developed a credible relationship with the local landowners by making sure we had permission to walk the stream. We didn't just go out and do it. I think people respect that. I think people respected the fact that there was an advisory committee of farmers. So in the early years we were building awareness, trust, and credibility because of the thoughtfulness of the work that was going on."*

As a result of their efforts to build trust among farmers, ISA and TNC personnel are well respected by the farmer respondents. Of the 13 farmer respondents who had an opinion on ISA personnel, all expressed positive views. A number of farmer respondents stated that they would not have been as involved with program outputs if it were not for their relationship with one or more of these program leaders. When asked why he got involved with watershed planning meetings, one farmer stated,

> *"Well I had enough respect for Iowa Soybean Association that they called and asked - I couldn't tell them no because I'd done so much work with them and I appreciated what they'd done."*

Having a trusted relationship with an individual program leader can, furthermore, override mistrust in that person's employer. For example, although all farmer respondents expressed mistrust of "the government," many participants named a specific NRCS contact as a primary source of information and support. Farmers also discussed relationships with watershed coordinators and ISA personnel. A number of respondents named and demonstrated a great deal of respect for a contact who was specifically involved in outreach. This individual already had personal relationships with many farmers before becoming involved in the BRW program. Farmers trusted this person as a source of information, and as a result he has been able to engage a number of resistant farmers and raise greater awareness about BRW program outputs. When asked about this program leader, one farmer responded,

> *"He put out a lot of flyers and the [farmers] that immediately respond… he went out and did some hands-on with them and continued to try and talk to people and have meetings. He's been very, very good at trying to inform the public as to what's going on."*

In addition to raising awareness about cost-share practices, this outreach leader helped farmers become more comfortable with a practice they may initially view as too risky. For example, BRW farmers were particularly worried about cover crops, which require changes in management that can affect profitability. In the BRW, cereal rye is the most popular cover crop because it can survive harsh winters and provide a significant amount of biomass in the spring. Farmer respondents frequently expressed concern about killing the rye, however, as it can have an allelopathic effect on corn and must be killed 10 – 14 days before planting. The outreach leader took the time follow-up with farmers multiple times, explain practices in detail, and encourage them to attend field days. One farmer explained how this approach prepared him to try cover crops, despite his initial hesitation,

> *"And then it was the following spring in 2011 when [the outreach leader] called me up and said, 'would you be interested in trying a little bit?' And I said, 'how much?' And he said, 'well, 20 acres.' And I said, 'well let me give it some thought.' Then I talked to him maybe another time or two and 'can I just put it in the same or can I rotate it back and forth?' And he said, 'well we'd like to keep it in the same place.' Because I thought I would do it all on soybean stubble. I went on the internet and typed in 'cover crop' and started reading about it and started realizing well there's some benefits to it."*

Farmers who have relationships with program leaders are also more informed about the state of water quality in the BRW. Although there is a large body of data and research that indicates agricultural nutrients are degrading water quality in the BRW, the majority of farmer respondents had not seen that information. These respondents often believe water quality is not a problem in the BRW or, if it is, urban areas or other farmers contribute the bulk of nutrient pollution. A 2010 survey of BRW farmer and landowner attitudes reveals that well over half of respondents believe they perform better than average at conserving soil and water resources (IDNR 2012). In contrast, we found farmers who were most involved with program outputs 1) knew that water quality was a problem in their area, 2) understood that nutrient pollution in the BRW originates predominately from agricultural sources, and 3) accepted the possibility that they might be losing nutrients and soil from their fields. Our research further suggests that when combined with water quality data, personalized data such as tile-line samples or soil tests are powerful tools to help farmers overcome common misconceptions about nutrient loss from their fields:

> *"Working with [ISA staff], that's given me a lot more insight than I would have had otherwise and it encourages me to keep doing what I'm doing. I think if other*

> *farmers knew that their water was high in nitrates they might think 'well, maybe I am part of the problem,' but most people don't know that."*

Despite misconceptions about water quality and personal contributions to nutrient loading, farmer respondents were open to receiving personalized data. Of farmer respondents who were unaware that tile-line sampling was an MRBI cost-share practice, all expressed interest in the practice. These respondents also emphasized, however, that tile-line data would have to be collected, stored, and analyzed by a trusted source. Farmer respondents feared that the data could be used against them, especially if the state enacts stricter water quality regulations. This finding indicates that program leaders with high social capital –particularly those who do not work for a government agency – are better positioned to collect tile-line data. When asked whether he would be interested in seeing water quality data from his tile-line, one farmer stated:

> *"As long as there wasn't a penalty involved. If it came back and something was 'whoa you're letting a lot of nitrates out, we're going to plug this tile line.' If there was no adverse effects, sure I'd love to see that kind of data. If a guy thinks it's going to harm him at all, no way."*

In addition to helping farmers gauge their own contributions to nutrient pollution, personalized data from tile-line samples, stalk nitrate samples, tissue tests, and/ or soil tests also help them manage nutrient and soil movement on their fields. For example, see quote above on a farmer's perspective on denitrifying bioreactors. Farmer respondents who found personalized data useful in assessing their management decisions were more likely to remain engaged with program outputs and to experiment with new practices. Other farmers watch these conservation-leaders to determine whether a new practice is safe and beneficial enough to incorporate into their own operation. One respondent echoed a common sentiment within the farming community when he stated, *"Mostly the people we've got around here now are the good farmers. Most of the others have been weeded out. The guys that are really going at it are, yeah I would believe anything that they told me and they do a good conscientious job. The guys that are doing [cover crops and strip-till] I would say... if they make it work we would probably look at it. "*

To capitalize on this element of farming culture, program leaders have begun to identify and support "farmer champions" to talk to other farmers about practices such as strip-till and cover crops. Once again, program leaders draw on relationships with these farmers to ask them to host field days and speak at meetings. Research indicates that farmer champions in the BRW have positively influenced how their neighbors view new management practices. As of 2012, for example, program leaders knew of at least six farmers who adopted strip-till because a local farmer champion allowed them to use his equipment. This finding is particularly significant because many farmer respondents said they were hesitant to buy a strip-till rig without first trying the practice.

Our research indicates that while financial resources (e.g., cost-share payments) can entice farmers to try a new practice, social capital is equally as important to long-term farmer engagement. Farmers who indicated an ongoing relationship with program leaders were more knowledgeable about water quality issues, more willing to try new practices, and more likely to become "farmer champions." This finding indicates that partners must build social capital within the farming community if they are to achieve water quality objectives; however, funding structures traditionally have not funded long-term outreach positions. To overcome this barrier BRW partners have augmented public funding with private funding sources, and are now working to more fully engage agronomists as program leaders.

Discussion

Within the resilience literature the concept of a "scale challenge" can be used to describe a situation where the temporal, spatial, institutional, and social scale of management does not match the scale or level at which social-ecological processes occur (Cumming et al. 2006). Our study demonstrates that this theoretical perspective is useful to describe some of the barriers faced to resilient watershed programming. Within the context of the BRW, we identified institutional, temporal, and spatial scale challenges that make it difficult to measure program progress, build social capital, and engage farmers in long-term water quality management. Furthermore, our data demonstrate how multi-stakeholder collaboration in the BRW has enabled partners to create a more comprehensive adaptive framework than would be possible without cross-sector involvement. We discuss our findings along with recommendations to guide future multi-stakeholder watershed management efforts in the BRW and beyond.

The importance of social monitoring

Partner respondents stated that a primary program objective was to engage farmers to positively influence water quality across multiple spatial levels. To continually learn from past outputs and improve future efforts, partner organizations use an adaptive framework to guide program management. As part of that framework, BRW partners combine private, non-profit, and public funding to maintain an extensive water quality monitoring and evaluation network. Data from this network have guided program planning and implementation, and in time will likely help partners evaluate progress towards watershed nutrient reduction goals. Because water quality responds slowly at a landscape scale (Meals et al. 2010), however, BRW partners must collect data over many years before they will be able to detect water quality improvement.

To evaluate how water quality responds to land-management changes at finer spatial scales, partners compare tileline or sub-basin water quality data to agronomic and farm management data. Government funding restrictions and time frames, however, have made it difficult to collect the biophysical data needed to measure change at the field- or farm-level. For example, while the MRBI/ EQIP edge-of-field monitoring standard (CPS 799) calls for baseline data collection (NRCS 2010) the time-frame of the MRBI project did not enable BRW stakeholders to collect baseline tile-line samples or agronomic data before farmers implemented practices. Without baseline data, it will be more difficult for partners to evaluate whether conservation practices have the intended effects on field- or tile-shed level water quality.

While water quality and agronomic data provide vital feedback on biophysical dynamics within a watershed, temporal and institutional challenges make it difficult to use that information as an immediate feedback on program outputs. Water quality responds slowly at the HUC-12 and HUC-8 levels (Meals et al. 2010), and barriers caused by a combination of funding restrictions and drought conditions have made it difficult to collect baseline data at finer spatial scales. Furthermore, biophysical data only measure the ecological progress towards objectives that are both social and ecological in nature. BRW partners therefore recognize that social evaluation is also an important assessment tool. Our research provided them with insight into the effectiveness of their various outreach strategies, how farmers view certain practices, and how to improve communication between partner organizations. They plan to use our findings and recommendations to guide future efforts at the program and farm level.

Given that "farmer engagement" is an intermediate indicator of progress toward the penultimate goal of improved water quality as well as an indicator of whether program outputs are acceptable to the rural community, we argue that instituting a social monitoring program in concert with biophysical monitoring is critical to the success of watershed improvement efforts. Social indicators of cultural and behavioral change would enable programs to more thoroughly gauge changes in farmer engagement as well as target outreach more effectively (Genskow and Prokopy 2008).

Engaging farmers in water quality management

In their study on farmer perceptions of perennial conservation practices, Atwell et al. (2009) found that, farmer "interview subjects viewed conservation practices, and their attendant government support packages, as more complex and less reliable than growing corn and soy" (p. 30). Our data are consistent with these findings, which suggest government cost-share programs are limited in their ability to promote widespread, long-term farmer engagement.

Among farmer respondents who were not as engaged with water quality management, we found that inflexible NRCS practice standards were a commonly cited barrier to trying a new practice. Because standards are written at institutional scales that do not necessarily translate to realities of farm-scale management, practice standards represent a scale challenge to widespread farmer engagement with water quality management practices. Whereas farmers must constantly adapt to shifting weather and economic forces, cost-share standards ask them to commit to several years of a specific management system. Farmers often fear that the standard will limit their ability to adapt quickly to contextual forces outside their control. This risk is compounded on rented ground, where rising rent prices leave no leeway for yield or profit loss. Because of the perceived hassle and risk associated with NRCS cost-share programs, at least to some farmers appear to have a zero-sum outcome in that the shared-cost benefit is off-set by perceived transaction costs.

Although NRCS cost-share programs enable interested farmers to try a new practice, our findings add to the growing belief that these programs are a limited tool that should be re-designed and/ or supplemented by other programs to engage enough farmers for a long enough period of time to observe water quality improvements. In the BRW, partners have long understood that many farmers are hesitant to sign an NRCS contract and aim to offer alternative water management opportunities. ISA, for example, supplements public funding with Soybean Checkoff dollars to write environmental management plans that do not require a contract. TNC has also helped a handful of farmers try strip-till and cover crops without having to sign up for a government program. While NRCS cost-share is an important tool, program partners underscored the importance of finding additional methods of providing cost-share and/ or technical support. This may also be the case in other multi-stakeholder watershed programs.

Building social capital

Consistent with other research on social-ecological systems, we found that farmer attitudes, beliefs, and ultimately decisions are affected by systems drivers outside their immediate sphere of influence and by social dynamics within their community (Atwell et al.

2009, Baumgart-Getz 2012, Reimer et al. 2012). We argue that watershed program staff should understand the primary drivers of change for the scale at which they work. For BRW leaders who work directly with farmers, for example, building relationships with farmers can be a powerful way to influence social dynamics at the community level. Our data indicate that the social capital gained through trust and ongoing communication has enabled program leaders to influence farmer beliefs regarding water quality and BMPs (Table 3).

Because NRCS respondents indicated they often are too busy to concentrate on outreach, it is difficult for them to build relationships with farmers, who in turn do not seek out their assistance. To temporarily overcome this gap, NRCS offices in the BRW were able to hire a coordinator through the MRBI, who is able to focus almost entirely on outreach. Because this individual was so effective at changing farmer perceptions of water quality and/or engaging them in MRBI practices, partners worked hard to find additional funding to maintain his employment beyond the initial, 4-year MRBI grant. Our findings suggest that hiring and training the people with high social capital with farmers, or the ability to quickly develop it, and establishing a long-term commitment to the outreach role would allow the NRCS to engage more farmers.

Where funding is a barrier to building outreach capacity in public agencies, our findings also demonstrate that private and non-profit partners in the BRW may be able to contribute to outreach capacity. In the BRW, ISA and TNC have been able to employ individuals who reach out to farmers to engage them in program outputs. While these individuals have high credibility among farmers, limited funding makes it difficult for them to work with a farmer for longer than a few years. To overcome this barrier, partners aim to engage local agronomists in program outputs, as local agronomists already have ongoing relationships and high credibility with farmers. BRW partners see agronomists as ideal allies to expand local buy-in of watershed management objectives. Our findings suggest that farmers also think agronomists should play a stronger role in watershed management efforts. Institutional and cultural barriers (e.g., time, co-op incentive structures, educational gaps), however, have made it difficult for partners to engage agronomists with program outputs. Because agronomists and local co-ops could be a source of long-term social capital in watershed management programs, we believe there is a need for further research on how to develop them as program leaders. We suggest examining university curricula and co-op incentive structures that serve as key barriers to agronomist engagement. We also suggest a need for stronger relationships between NRCS and co-op offices.

Conclusion

Despite widespread public concern over local and national surface water quality, structural drivers such as commodity prices, land values, cultural norms, and policy create an agricultural system which is resistant to change. As Iowa moves forward with the Nutrient Reduction Strategy (Iowa 2013) watershed initiatives such as the BRW program offer insight into the role of multi-stakeholder collaboration can play in creating the systemic change necessary to improved water quality. Our case study demonstrated that, while partners had to act within a system in which scale mismatches present obstacles to comprehensive watershed management, private-public partnerships strengthened resilience at the program scale as well as on the ground.

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Table 1: *Timeline of Boone River watershed initiative projects and grants*

Dates	Project Title	Grant or Funding	Location	Partners Involved	Outputs	Intended Outcomes
2004 - 2008	Conservation Action Plan	EPA, Cargill	BRW	TNC, BRWA, IOWATER, NRCS, ISA, ISU, RC&Ds	Conduct assessments and write plan for entirety of BRW	Provide a plan to improve biodiversity in the BRW
2004 - Ongoing	Management Evaluation	ISA, TNC, Various grants	Two HUC 12s in the BRW	ISA, TNC	Stalk nitrate sampling, data interpretation	Help farmers evaluate and manage nitrate applications
2004 - Ongoing	CEMSA/ ADAPT	ISA, Various Grants	All over Iowa	ISA, RC&Ds, ACWA co-ops, agronomist contractors	Work with farmers to write EMS plans, collect and interpret data	Help farmers implement and evaluate plans to manage natural resource concerns
2004 - 2006	Rapid Watershed Assessment	RC&Ds	Multiple locations; All of BRW	IDNR, ISA, NRCS, RC&Ds, TNC	Stream-bank assessment, discuss resource concerns with farmers	Assess stream-bank conditions, build relationships, targeting
2004 -	Boone River Watershed Association	RC&Ds	BRW	ISA, TNC, RC&Ds, SWCD, NRCS, local stakeholders	Facilitate stakeholder meetings, write watershed plans, build relationships	Coordinate BRW stakeholders to align partner and farmer objectives
2007 - Ongoing	Three-tier Water Monitoring Network	ACWA, TNC	Main-stem, 30 HUC 12s, sub-basins in Lyons Creek	ACWA, ISA, DMWW, TNC	Collect and analyze water quality data on multiple scales (tile-shed, sub-basin, HUC 12 and HUC 8)	Evaluate baseline conditions, target areas of concern, evaluate BMP efficacy, and leverage funding
2008	Watershed Planning for Lyons Creek	IDALS & IDNR Planning Grant	Lyons Creek	ACWA, ISA, RC&Ds, NRCS	Meet with farmers, write watershed plan for Lyons Creek	Guide multi-stakeholder adaptive watershed management in Lyons Creek

2008 - 2011	Cooperative Conservation for Watershed Health (CCWH)	ACWA, NRCS CIGs, Soybean Checkoff	Lower Eagle, Buck, and Lyons Creek	ACWA co-ops, ISA, NRCS, TNC, local agronomists	Teach CCAs to write CEMSA plans, work with farmers to write CEMSA plans, link farm and watershed plans	1. Build local technical capacity 2. Link farm and watershed plans, 3. Evaluate farm energy use
2008 - 2010	ACWA Bioreactor Demonstration Project	ACWA and SCF	Raccoon & Des Moines River watersheds	ACWA, DMWW, ISA, Sand County Foundation	Install and test 4 - 6 bioreactors, work with NRCS to develop cost-share practice standard	Evaluate efficacy and feasibility of bioreactors, disseminate bioreactors more widely within the BRW
2009 - 2010	Operator and Landowner Survey	ISA	Lower Eagle, Buck, and Lyons Creek	ISA, J. Arbuckle - ISU extension	Survey Buck, Lower Eagle, and Lyons Creek farmers and landowners	"Provide social, economic, and behavioral data on farm operators and landowners"
2010 - 2013	Targeted Nutrient Removal in the BRW	USDA-NRCS MRBI Grant	8 Huc 12s in southeast of BRW (See map)	ISA, NRCS, TNC	Provide farmer with cost-share and technical support to implement BMPs	Reduce nutrient loading, improve habitat, and maintain agricultural production in the BRW
2010 - 2013	Prairie Creek Watershed Project	USDA-NRCS MRBI Grant	4 HUC 12s in northwest of BRW (See map)	ISA, NRCS, TNC	Provide farmer with cost-share and technical support to implement BMPs	Reduce nutrient loading, improve habitat, and maintain agricultural production in the BRW
2011 - 2014	ACWA MRBI-CCPI	USDA-NRCS MRBI Grant	8 Huc 12s in southeast of BRW (See map)	ACWA, ISA, NRCS	Increase payment rates and flexibility of NMPs, work with farmers to implement NMPs	Help farmers adopt nutrient management plans and technologies
2012 - Ongoing	Oxbow Restoration	FFP, ISA, IDNR, SCF, TNC, USFWS	White Fox , Lyons, Eagle, and Buck Creeks	FFP, ISA, IDNR, SCF, Hamilton and Wright SWCDs, TNC, USFWS	Restore oxbows in BRW, monitor water quality and conduct fish surveys in oxbows	Provide habitat for Topeka Shiner, sequester nitrogen from streams

Table 2: *System model theme and sub-theme descriptions with supporting quotes*

Theme	**Sub-Theme**	**Description**	**Partner Quote (Program Scale)**	**Farmer or Agronomist Quote (Individual Scale)**
Contextual Ecological, Political, & Socioeconomic Influences	Contextual Ecological, Political, & Socioeconomic Influences	This theme represents those forces that directly impact stakeholder actions at all levels but which we do not directly address in this paper. For example: drought, the delayed farm bill, rising commodity prices, etc.	There's so much [farmers] can't control that has a major effect on their income and their success and their life. The major thing being climate but also markets... so I think they're very hesitant to lock into a practice over a period. [They think], 'now I might do it this year... but I don't know what's going to happen weather-wise and if I lock into that practice I could be up the creek.'" (PP 2)	"The high-cash rent, high price of grain, we're starting to see some of these buffer strips getting taken down now and not put back in which is kind of sad to see. But we've had two years and not a lot of rain. People forget what can happen." (F 3)
Outside Funding Structures	Outside Funding Structures	Outside funding structures set restrictions on funding sources not under direct control of BRW program partners.	"It would be nice if we had one long project with a reasonable amount of funding over a long period of time, but we've been successful at cobbling together little projects to keep some work with these guys going. The Boone River is the only place we've been able to stay as long as we have... So, if there's an ideal location for this kind of back and forth between you know, a watershed plan versus an individual plan, we'll be able to do it in the Boone River." (PP 4)	"I realize that there's programs that [come] close to getting you that money back, but I don't know if it's quite doing it. And we don't know what the government's going to do. That program could go away." (F 10)

Outside Funding Structures	Amount	This theme refers simply to the amount of funding available to the program at any given time.	“We should be providing more verification and things like that. They really want a research grade. In particular… the edge-of-field monitoring standard that's implemented as a part of MRBI. You know, they have these huge hopes for what that could or should be, but the reality is from what they're giving they're not gonna get… you know, it costs a lot of money to do that.” (PP 7)	“That’s the only reason I was interested in [cover crops], 'cause at that time they were paying like... $108 an acre per year for 3 years and my out of pocket costs were going to be around the $55 figure. With that I was interested in it. But that- then they cut it down 'til it just barely covered expenses, and then I was definitely no longer interested in that program." (F 14)
Outside Funding Structures	Time-frame	Funding periods are variable in length. Public funding usually must be spent within 6 months - 4 years. Private funding is more variable. Private partners such as ACWA, ISA, and TNC have provided funding for the duration of the program.	"We need good planning and we need to have resources. Here's another challenge that we have: we get funding one year at a time. And the reality is these are multiyear issues. And frankly we've risked a lot just saying, “Here's what we're gonna do,” despite the fact that we don't have all the funding we need going forward with this." (PP 13)	"This process that goes on in NRCS, you show your interest and then they say well we're still refining the rules and we're still doing this. I think I went in October of 2010 and it was probably January or February of 2011 before I actually found out that I could be enrolled into this program based on the points." (F 7)

Access to Funding	Access to Funding	Funding may come from outside public or private sources or directly from program partners. Partners use private funding to leverage outside funding/ matching grants.	"Are we hoping to entice more dollars up there... by demonstrating success? I would say the answer to that is yes. It's important to know whether what we're doing is working or not. And if it's not working certainly that's not the type of thing that we want to be funded... And I think the funders will see that. They wanna see a track record of success." (PP 1)	"When you're not the one making the decisions on how much tile is placed and you've got landlords that maybe don't want to spend the money on tile, but still want to have the top rent you cannot sacrifice your yields. And this was the concern that I expressed to them, I would gladly adopt [cover crops] there, but it takes a lot of money to switch your entire operation over to it." (F 13)
Partner Alignment	Partner Alignment	A key element of the BRW program is its emphasis on aligning public and private partners with diverse primary interests. An indicator of program success is how well partners combine expertise to engage farmers, attract funding, and implement adaptive management.	"Everybody has a mission… obviously organizations are gonna overlap in their missions and of course whenever that happens that can either be beneficial where the efforts of the organizations are enhanced - where the sum is greater than the individual parts. Or you can work at cross purposes with one another... And so that's one thing we talk about a lot, is how to align our efforts with other organizations and agencies where there is overlap. So that the combined efforts are enhanced and we're not diminishing one another." (PP 1)	"Showing some [farmers] the way towards a cost share program I think is a great thing. It's just sometimes being the middle man our knowledge on that is sometimes lacking at best. Not really knowing what the programs all entail I guess. And I'm not blaming that one anyone it's just as much my fault as anyone else's." - (A 2)

Partner Alignment	Communication	Communication between partners may be strategic or organic. Strategic communication may occur at regular meetings or through e-mail updates. "Organic" communication occurs when leaders from partner organizations maintain relationships and contact with each other.	"Yeah, I think there's definitely a disconnect between what the management of the co-ops are trying to do with ACWA and what the agronomists are doing with the farmers. My feeling is that the management wants to put forth this monitoring effort and at least look at nitrate levels in the rivers. But then when it comes to making changes at the farmer level, the agronomists, it's their job to sell products. So they're not so much concerned with doing the best practices, they're going to do what's best for agronomic production and what the farmer wants.” (PP 12)	"If they have particular concerns that could be alleviated by use of the cover crop or use of strip-till or no-till or something like that, I will bring up those management strategies. But I don't necessarily go out and say, Farmer X, let’s talk about cover crops today.... As a Co-op we're not going to stay open by selling rye cover crop seed. The money is made in chemicals and seeds so that's what I did before and that's what I do." (A 3)
Partner Alignment	Credibility	Partner organizations are considered credible by different types of stakeholder groups. For example, farmers may view ISA as more trustworthy, whereas environmentalists may engage with TNC.	"We worked really hard to make sure that we developed a credible relationship with the local landowners by making sure we had permission to walk the stream. We didn’t just go out and do it. I think people respect that. I think people respected the fact that there was an advisory committee of farmers. So in the early years we were building awareness, trust, and credibility because of the thoughtfulness of the work that was going on." (PP 13)	"Well I had enough respect for Iowa Soybean association that they called and asked - I couldn’t tell them no because I’d done so much work with them and I appreciated what they'd done." (F 1)

Partner Alignment	Capacity	Partners also have different types of capacity depending on their institutional structure, funding, employees, expertise, and workload.	"We're asking the local watershed community to think much bigger about the potential of their area. That is different than dispensing cost share and administering traditional programs. It requires some human resource capacity, infrastructure capacity, somebody owning and managing these plans. If you're going to have that, it takes money. Where does that money come from to do that? That's a significant challenge." (PP 13)	"I don't know. My impression is that NRCS don't have a lot of time to do [nutrient management planning]. They're trying to do a lot of stuff without very much money. Not everybody in a given field office knows that much about nutrient management. So, I think it's a matter of limited resources." (A 4)
Partner Alignment	Cause	Cause refers to each organization's priorities and mission (Environmental, agronomic, business, recreational, etc.)	"The Iowa Soybean Association, Nature Conservancy, the Soil and Water Conservation District, and us [NRCS] - we're all looking to reduce nitrogen or reduce all of the micronutrients and major nutrients in the water supply. And we just go about it in different ways. That's what is so nice, because they each have their expertise." (PP 8)	"So, being a co-op, we are owned by the farmer. We have members that own us and we have a board that is elected by the farmer… We handle the grain and merchandizing of the product and my job is I sell seed, fertilizer, and chemicals to them and give them agronomic advice through the year... And if we're doing a good job patronage is really good as well as some of that money is reinvested into better equipment for the farmer, better facilities, you know, bigger faster better." (A 1)

Adaptive Management in the BRW	Monitoring & Evaluation	Monitoring and evaluation are closely linked. Different types of monitoring data are evaluated to assess whether partners are on track to meet biophysical and social goals.	"So we have all this data and we say our intention is that the data is there to be an evaluation tool and an assessment tool. An assessment on the front end to say 'what's the baseline here, what needs to be done?' To put that into the planning process - that assessment data... and then that monitoring is a part of evaluation. To feed back into the planning process in an adaptive management cycle." (PP 2)	"It's been hard to tell the last couple of years just because it's been so weird. I mean we go from I think two years ago like ten inches of rain at one time and then we went to almost none all summer last year - like an inch and a quarter all summer. So... haven't gotten real, true data as to what is going on with water. But [ISA contact] gives us a full report every year after he's done with every site that he pulls water from and what dates... so we know parts per million of everything that's going out there. And Dad saw a huge change in through the bioreactor." (F 4)
Adaptive Management in the BRW	Monitoring & Evaluation: Water Quality	Water quality monitoring involves multiple scales of data collection and analysis. Water quality data are collected at the tile shed, sub-basin, HUC-12 and HUC-8 levels. BRW partners primarily are concerned with nitrate, but also measure other indicators of water quality.	"We have one guy… he's super interested in it. He tells me stuff about cover crops. He's always researching it. He's got - with these bioreactors there's a weather station that comes with it - on his yard that he can keep track with his computer the weather data. So he's really involved with it, whereas others are in between like, 'Yeah if you have some data, I'd like to have it if you could send it or whatever.' The data, they want to know about it, I think how their fields compare… If they can say their fields are just as good or better, then that helps us in selling cover crop." (PP 8)	"One of the interesting things about the bioreactor is they test the nitrogen coming in and they test it going out. I guess I'm more concerned with the water coming in because it's coming out of a field that's been no till for 7 to 8 years and then cover crop. I'm interested in how much nitrogen we're retaining in that field. Because look at all the fields around. You can't build a bioreactor for all these fields. I don't think, maybe they can but I'm more interested in the practices that hold the nitrogen in there so you don't need a bioreactor." (F 2)

Adaptive Management in the BRW	Monitoring & Evaluation: Agronomic	Agronomic data are collected to guide planning and adaptive management at the field and farm level. Agronomic data include results from stalk nitrate samples, tissue tests, soil tests, p-index estimates, strip trials, etc.	“If you measure something on somebody’s farm and tell them this is the number, this is where you relate to things around you… If you try something next year, we’ll do it again and then you can see the difference between the two… I think it also gives them an idea how variable the things like nitrogen use efficiency and nitrogen loss can be to the weather… There are other areas than just yield.” (PP 7)	"With [the crop consultant] it’s primarily working on the soil samples and results he brings back to us. It’s the more information we can use and make our own decisions on how to fertilize, where and when those kind of things." (F 11)
Adaptive Management in the BRW	Monitoring & Evaluation: Social	Social monitoring involves collecting data on indicators of social or cultural change, which can then be used to guide outreach and marketing efforts.	“Are farmers continuing to find value? If we did some planning work and some stalk testing and some performance feedback in the early years is there value to them to come back and look at that again?... We really don't have good feedback on what's actually implemented or what impact or change we have on farm practices. So because of the nature of funding we get a grant to go work with the farmers and write a plan and then you get another grant to go work with another group of farmers and write another plan, rarely do we have the opportunity to go back to that original set and say… update me on what's changed in your operation and why.” (PP 3)	"I think we’re becoming much more comfortable around here with strip till. We’re particularly we’re hearing another neighbor or hearing somebody - particularly a farmer that is considered to be a good farmer. If we get a few of those guys strip tilling it suddenly becomes a little more acceptable." (F 1)

Adaptive Management in the BRW	Planning	Partners in the BRW attempt to link farm planning to goals for the watershed plan. Implementation of watershed plans is difficult because land is privately owned - farmers on key parts of the landscape may choose not to engage with environmental management plans or BMPs.	"They specify so many acres of different practices, particularly... the one that has a DNR grant to write the plan. That one is very specific, this is the load reduction we need by a certain time. And to reach that load reduction, we have to implement this many acres of nutrient management planning... We have to implement this many acres of cover crops. This many bioreactors, that kind of thing. That is specifically spelled out in the watershed plan. And then our process we hope will encourage farmers to go in and sign up for those cost-share programs that help them do that through the individual planning... But again, we don't really spell that out in the individual plan." (PP 3)	"I think the farmer input was used to establish a guideline of maybe what farmers think and maybe here's the urban thoughts, here's the farmer's thoughts and try to meld them together. I think that was real helpful." (F5 talking about watershed planning meetings)

Adaptive Management in the BRW	Targeting	Targeting occurs at different scales. Based on monitoring data, a program may focus resources on a sub-basin or set of sub-basins. Targeting may also involve outreach to a few individuals who have a strong impact on ecological or social processes in their watershed.	"The Lyon's Creek plan really called for doing this BMP map… The challenge is you needed enough flexibility… we were making some assumptions based on proximity and based on the assessments we had done, not the individual person who was farming that piece of ground when we did the watershed plan… One of the discussions is are you targeting just those that come in the door… or do you go out and make cold calls and target those areas that you've identified through assessment as being the most vulnerable?" (PP 4)	"Be more selective on those areas that are in dire need... like I said those three or four acre patches that are just farmed because they are going to get almost nothing off of it through the CRP. I think that would be big too. And that just widens out our buffer along some of those creeks and I think that'll help." (A 2)
Adaptive Management in the BRW	Outreach	Outreach refers to any effort by program partners to engage watershed stakeholders - primarily farmers, landowners, and agronomists. Outreach efforts may occur through face-to-face contact or marketing campaigns.	"My major role is to educate and recruit farmers for practices, conservation practices for the MRBI... To be successful you gotta talk to them face to face. It seems like, and it might take three times. The first time they're aware of it, the second time more explanation and then they're more willing to attempt some of these practices. So my role is to go out, get them interested, get them educated about it, get them in the office to answer more technical questions, and then they're handed over to somebody else to deal with that." (PP 8)	"He put out a lot of flyers and the ones that immediately respond… he went out and did some hands on with them and continued to try and talk to people and have meetings. He's been very, very good at trying to inform the public to what's going on." (F 5)

Adaptive Management in the BRW	Outreach: Cost-share	Cost-share funding helps farmers cover the added expense and potentially the added risk of a new BMP. Funding may come from public or private funding. Cost-share payments are the traditional way of incentivizing BMP adoption.	"And then you can hopefully throw out there, 'Well we've got some funding, some incentive payments to help get you started to adopt that practice.' And maybe we rely on that a little too much." (PP 12)	"Well honestly at the beginning it was 100 and some dollars an acre to do it, and now it's down to like $40 well by the time you spend the extra time to go out there in the spring to kill it and spend the money on the rye and the application you're really not making any...I mean it's not beneficial money-wise for us to do it. And if it happened to ding our yield at all..." (F 9) "... It's just not something we're willing to risk." (F 8)
Adaptive Management in the BRW	Outreach: Relationships	Program leaders who work directly with farmers and landlords are able to form relationships with those stakeholders.	"The employee in the Boone River… farmed near the Boone River. He was up there three or four days per week, meeting with, talking with, doing stuff with his producers. That was a very effective way of achieving their engagement, because [he] could talk about the issues because it was the same issues he had on his farm in the Des Moines River watershed, which was essentially right next door to the Boone. So that's probably the number one way we've been effective." (PP 3)	"So I know three guys that have put in bioreactors right around us that are both that are on waterways or a dredge ditch or a river. I think they're the same ones that are doing cover crops basically. So I think that goes back to that working relationship with[Wright County NRCS Staff] again. And them letting us know what's available for us to use, what programs are out there, and how to help us qualify for them." (F 4)

Adaptive Management in the BRW	Outreach: Communicating Data	A primary goal among program leaders is to effectively communicate water quality and agronomic data to all stakeholder groups. Multiscalar data can then be used to guide planning and management decisions.	"I also provide updates to them with all the data shaken out… some farmers are more interested than others. One farmer is really interested. He likes to see it, so I also share our next tier monitoring, I guess you would say, with the water samples we get from [HUC-12]. He likes to see what the nitrate concentration is in [HUC-12] compared to what it is in his tile line. And this year, his tile line is actually lower than the stream, so he's pretty proud of that." (PP 5)	"So hopefully I can see some correlation between the practices that are implemented and the outflow of the water because that's kind of the desired goal of this whole project, to reduce the nitrates and the nutrients in the water." (F 7)
Adaptive Management in the BRW	Outreach: Technical Support	Program leaders support farmers to manage a new practice, collect and understand data, and meet management goals. Partners are working to expand technical capacity by engaging and training local agronomists.	"I think they're really trying to make all these connections happen between the crop consultants and the agronomists. That's probably where you're gonna get the boots on the ground and we really think it's important for technical assistance in the watershed. So these MRBI coordinators are crucial, the NRCS office doesn't have the staff for any outreach. It's basically people have to come into the office. If they don't come into the office, people don't get that information." (PP 5)	"We have a new agronomist up here at the local co-op and she's younger. She was talking about getting her nutrient management, whatever she needs to know to do that to write those plans. She hasn't done that yet. She has written a couple but she didn't know what she needed to do for sure. But she said she was looking at maybe doing that course online if she could and learn a little more about that. She seems really interested. The other agronomist up there, he's a little older so it's harder for change." (F 3)

Farmer Engagement	Farmer Engagement	Farmer engagement may be as simple as learning about water quality issues. Ideally, farmer engagement leads to adoption of multiple water quality management practices and maybe even land-use change.	"We're at least starting the process of educating people and getting those early adopters on board with some of the conservation practices… The test will be if we can get past those early adopters and get to the larger portion of the bell curve where we have significant adoption of conservation practices, that's where it's going to be tough sliding… We're always going to have a few people the first couple years of a watershed project do something just because they're innovative, they're conservation minded, they want to do it. But then what's gonna happen in years three through ten?" (PP 11)	"Talking with the MRBI coordinator, he discussed some of this. He says what we are trying to do here in the MRBI project is to get some of these things in place, show people they can work. Show EPA, show DNR, show the people in Baton Rouge that people in Iowa are trying to do something and they're taking steps in the right direction. So I thought, well I'd like to be part of that." (F 7)
Water Quality Improvements	Scales	The long-term program goal is to reduce nitrate concentrations throughout the BRW. However, it takes many years to detect nutrient reductions at larger scales.	"Trying to do stuff on a short time scale you really need very expensive, intensive monitoring to factor out all the other things that come into play. If you've got to measure the precipitation, soil temperatures, rotations… you have to really take all that into account, which I wouldn't say we're set up exactly to do that yet. Ours is more to target, to guide, and eventually we'd like to see some results and there's ways to do it but… we're not set up to do it that fast." (PP 7)	[The MRBI coordinator] shared a little bit of [the water quality data] with me. Yeah we're, he's finding that [nitrate] is getting in there. And the amount shocked me that I've seen from him. So we need to get better. (F 10)

Table 3: *Descriptions of best management practices (BMPs) for soil and water conservation and conservation programs commonly used in the Boone River watershed program*

Practice and program name	Description
BMPs	
Strip-till	In-field management practice. Tillage occurs along rows, while the spaces between rows are undisturbed. Benefits include increased ground cover, decreased soil compaction, improved infiltration, decreased erosion, others.
No-till	In-field management practice. Field is never tilled. Benefits include increased ground cover and infiltration, decreased and erosion, others
Cover Crops	In-field management practice. A cover crop such as cereal rye, hairy vetch, or tillage radish is planted in the late summer or early fall. If the crop over-winters it will grow in the spring and be terminated before planting. Benefits include ground cover for soil during winter and early spring, added organic matter, reduced leaching of nitrate, weed suppression, reduced erosion, others.
Nutrient Management Plans (NMP)	In-field management practice. We use nutrient management plan to refer to the NRCS standard (CPS 590), which restricts nitrogen rates, and does not permit fall fertilizer application. The ACWA MRBI nutrient management standards are modified to allow fall application as long as a nitrogen inhibitor is used.
Grassed Waterways	In-field management practice. Waterways are placed strategically to direct run-off, reduce sheet and rill erosion, and avoid gully formation
Environmental Management Plans (CEMSA)	Whole farm management. Environmental management plans are prepared by program personnel with the Iowa Soybean Association or affiliated agronomists. Plans include multiple years of data collection and analysis, as well as management strategies for nutrient and soil retention.
Denitrifying Bioreactors	Edge-of-field management practice. Tile-line water can be diverted through a bioreactor - a large pit filled with wood-chips and denitrifying micro-organisms - to remove nitrate before it is drained into a stream or ditch. It is possible to monitor the water entering and exiting the bioreactor for nitrate or other pollutants.
Oxbow Restoration	Riparian/ in-stream management practice. An oxbow is a U-shaped meander of a stream or river that provides valuable habitat and filters nutrients. Oxbows can be cut off when a river changes course or is channelized. Disconnected oxbows can be restored by removing sediment and allowing water to return.
Conservation Programs	
Environmental Quality Incentives Program (EQIP)	EQIP is a government program administered by the USDA NRCS that "provides financial and technical assistance to agricultural producers in order to address natural resource concerns and deliver environmental benefits" (NRCS 2014). Landowners work with the NRCS to design an EQIP plan for eligible land. They can receive up to 10 years of support to implement new conservation practices.
Conservation Reserve Program (CRP)	The CRP is a government program administered through the USDA Farm Service Agency with support from the USDA NRCS. Landowners can sign a contract and receive payments to plant highly erodible or sensitive land in perennial vegetative cover.
Conservation Stewardship Program (CSP)	CSP is a government program administered by the USDA NRCS. CSP provides five-year contracts to farmers who want to maintain and enhance existing conservation programs.

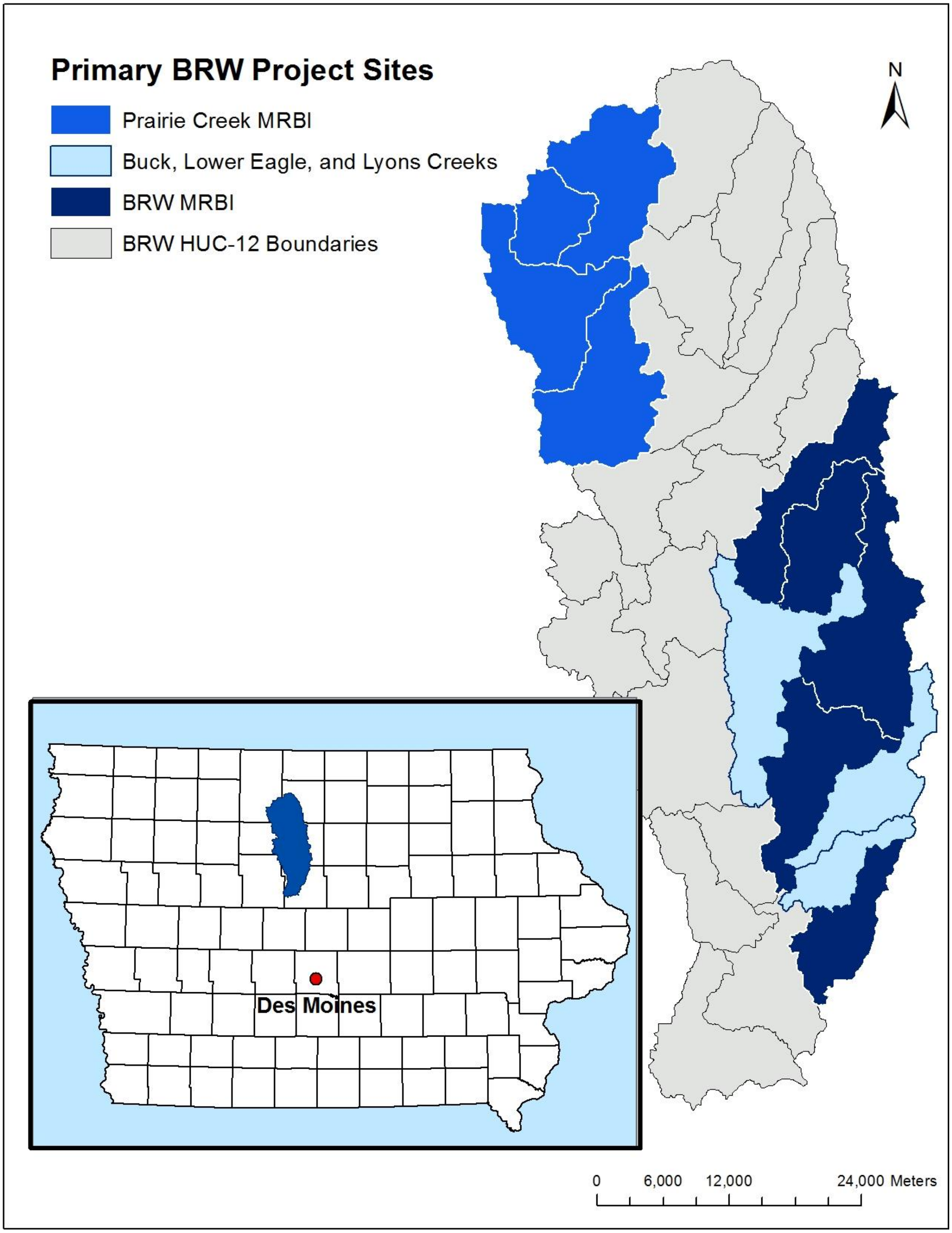

Figure 1: *Map of Boone River watershed initiative project locations*

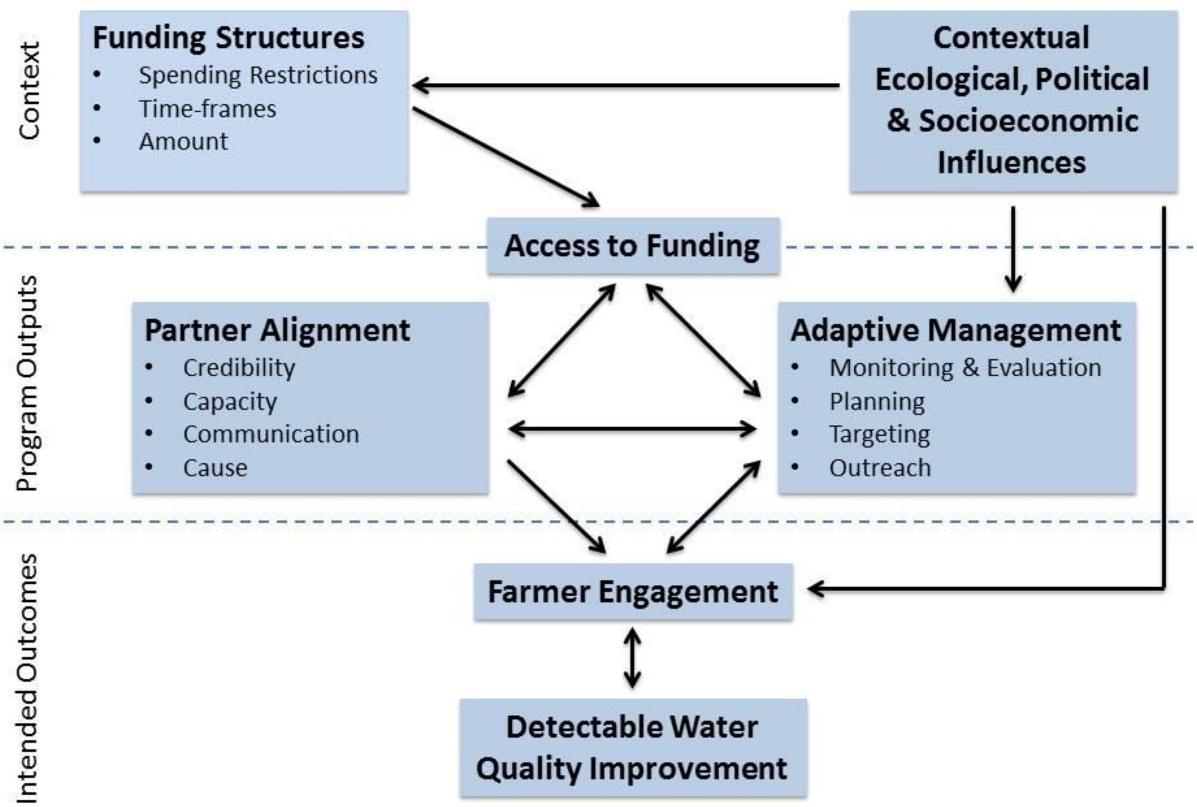

Figure 2: *Systems model of the BRW initiative and intended objectives*

CHAPTER 4

GENERAL CONCLUSION

The Boone River watershed program evaluation provided me with the opportunity to explore diverse perspectives on water quality management within the context of an agricultural watershed. As I spoke with respondents, new layers of complexity continually emerged and it became clear that meeting statewide nutrient reduction goals will be a monumental task. Socioeconomic barriers to change exist at every level of the agricultural system – from global economic forces to individual farmer beliefs about water quality and best management practices (BMPs). Many of these barriers are discussed in the chapters above.

My research – and the work of many others – demonstrates that barriers to agricultural change are primarily socioeconomic in nature. Because the forces inhibiting progress are primarily determined by human systems, they are within our control. Despite the complexity of those forces, this statement provides hope that "production agriculture" can be transformed into a phrase that encompasses provision of clean water and air, healthy soil, and recreation as well as food, fuel, fiber, and feed.

To shift system momentum towards a multi-beneficial agriculture, there is a need to explore "levers of change" at all socioeconomic levels. My research indicates that for those who work directly with farmers, relationships are one of the most important drivers of change. Relationships build social capital that can be utilized to influence farmer beliefs about water quality and comfort with BMPs. At the watershed program level, cross-sector partnerships encourage greater programmatic resilience and continuity. Policy-makers can clear the path for those working on the ground by providing long-term funding and support, removing obstacles to farmer engagement with conservation programs, and incentivizing the agricultural industry to become involved with water quality initiatives. Business leaders can continue to support sustainable agricultural initiatives such as the BRW program. Iowa farmers already identify as "stewards of the land," but they will need system-wide support as they shift from maximizing grain yield to managing for multiple goods and services.

As I learned about potential levers of change within our agricultural system, I asked a number of questions that time limitations did not permit me to explore. I believe, as did respondents from every stakeholder group, that agronomists and local co-ops could be invaluable partners for watershed management programs. Agronomists have frequent access to farmers and are trusted sources of advice and information. University-level curricula that train these individuals, co-op incentive structures, limited time for personal interaction with farmers, and agronomist culture appear to be major barriers to agronomist engagement, however. I believe further research related to these barriers and potential solutions would greatly benefit watershed management efforts.

An additional stakeholder group that is vital to widespread adoption of BMPs are the non-operator and absentee landlords. Because over half of Iowa farmland is rented, farmers no longer have direct control over a majority of the acres they manage. My findings suggest that landlords and high rent prices are major barriers to farmer adoption of conservation practices on rented ground. Further research is necessary to find methods to involve absentee landlords with conservation efforts.

As I reviewed my findings and remaining questions, I also identified methodological improvements I would make if I were to redo my evaluation. Although I interviewed a broad cross-section of program leaders, my data are lacking perspectives from those who are not involved in program efforts. On further reflection, I would interview additional agronomists, absentee landlords, and more farmers who have not been involved in BRW program outputs. Along with additional interviews, I would have been more purposive in my sampling methods. For example, I might have been more strategic about gaining a range of perspectives from Lyons Creek farmers. If time and money were factored out, I would have liked to survey farmers and landowners from Lyons, Lower Eagle, and Buck Creeks to determine if attitudes had changed since Dr. J. Arbuckle conducted his survey in 2009 – 2010. The MRBI project started after that time and it would be valuable to gauge short-term effects on farmer attitudes and engagement.