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The farmer and farm networks: an examination of conservation adoption in the U.S. corn belt

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The farmer and farm networks: An examination of conservation adoption in the U.S. Corn Belt

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DEDICATION

I would like to dedicate this thesis to my husband Andrew Bates; my parents Janice and Jerry Rosman; and my sisters Laura, Carrie, and Alicia.

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ABSTRACT

Over the last several decades, the negative effects of nitrogen and phosphorus pollution on aquatic and marine ecosystems have been increasingly well-documented. Nutrient fertilizers run off of farm fields, enter regional waterways in the Mississippi River Basin, and ultimately accumulate in the Gulf of Mexico. As a response, in 2013, the State of Iowa released the Iowa Nutrient Reduction Strategy that outlines goals to reduce losses of nitrogen and phosphorus into waterways for both urban and rural contributors. The Iowa Strategy, which is a voluntary approach to addressing water quality impairments, outlines a series of conservation practices that farmers can use on their farms to reduce these losses.

This thesis is a sociological examination of conservation adoption among corn and soybean farmers in the U.S Corn Belt Region of the United States. In the text, we pose the following questions: What are the social network factors that are associated with the diversity in the nutrient management practices used by farmers? How do farmers who are recognized as exemplary stewards build resilient farming operations? These questions are explored through the lens of a theoretical framework that uses the diffusion of innovations theory and complex adaptive systems theory. Both qualitative and quantitative methods are used to address the above research questions. Findings from this research show that contextual and social network factors may have a significant impact on conservation adoption. The thesis concludes with a discussion on implications our findings may have on current nutrient reduction policies in agriculture as well as future research directions in understanding conservation practice adoption.

CHAPTER I

INTRODUCTION

In Iowa, corn and soybean production has a significant influence in the agriculture sector and the overall state economy. Iowa ranks first in corn and soybean production among other agriculture commodities in the United States. In 2012, Iowa produced crops valued at more than $17.3 billion, with corn and soybean production making up the principal segment of the state's agriculture economy (USDA 2014). In the same year, 13.7 million acres were in corn production and more than 9.3 million acres were in soybean production in Iowa (USDA 2014). The dominance the state has in agricultural yield output is the result of research and technological development in sustaining productivity increases in Midwestern agriculture. Achieving yields on the farm is the product of technological processes that include genetically improving plant varieties, managing crop interaction with the environment, and persistently improving farming practices and on-farm decision-making (Moschini 2014). The pressure for agriculture productivity is increasing due to global food security demand, fiber production, and energy production, which has significant consequences on sustainable crop production and aquatic ecosystems (Tilman et al. 2002).

Intensive agriculture that produces corn and soybeans is an environmentally leaky system. Farm agroecology is often managed in isolation from other regional ecosystems, but the ecological transformations that take place have significant impacts on neighboring and far away ecosystems (Matson et al.1997). In 2012, a majority of rivers and streams were assessed as impaired in Iowa (EPA 2012). Excess nutrients from agriculture fertilizers that support corn and soybean production impair water systems beyond individual states and add to the hypoxic or "dead zone" in the Gulf of Mexico (Diaz and Rosenberg 2008, Boesch et al. 2009; Rabotyagov et al. 2014).

In 2013, the State of Iowa released a Nutrient Reduction Strategy in response to ecological impairments and to establish goals to reduce the amount of nitrogen and phosphorus that pollute waterways. The Iowa strategy was encouraged by the 2008 Gulf Hypoxia Action Plan that calls for states to develop nutrient reduction plans to meet the overall goal of at least a 45 percent reduction in the amount of nitrogen and phosphorus that enters the Gulf of Mexico (ISU 2012). The Iowa strategy established a goal of a 41 percent reduction in nitrogen and 29 percent reduction in phosphorus (ISU 2012). The Iowa strategy recognizes that there is no individual conservation practice that can achieve these goals, and so farmers need to use a diverse number of practices to make any impact (ISU 2012). Alongside the Iowa strategy, the State of Iowa established the Iowa Farm Environmental Leadership Award program to recognize and promote those who have taken extraordinary steps to implement conservation practices on their farm fields.

The Iowa strategy, which is a voluntary approach, uses several policies and programs to assist farmers in reducing nutrient losses from farm fields. These include: conservation outreach, promotion and cost-share funding for nutrient management practices, and watershed pilot projects, among other approaches (ISU 2012). The Iowa Farm Environmental Leadership Award program is an effort by the state to promote conservation behavior by recognizing and publicizing family farms that adopt conservation practices and take conservation leadership roles within their communities. The objective of the program is to showcase these farm families as role models for how others in Iowa can incorporate environmental stewardship into their farming operations (IDALS 2014). These efforts will be further explored in the papers included in this thesis.

Current research in support of agriculture conservation contains numerous shortcomings. A significant focus has been on farm characteristics, environmental awareness, and attitudes in relation to individual conservation practices or a set of similar practices rather than the full array of practices available to farmers (Prokopy et al. 2008). A meta-analysis by Prokopy et al. (2008) shows that some social factors may be associated with the adoption of discrete conservation practices, such as education, social networks, and information access. In this thesis, we seek to address the gaps in current research approaches by examining the effect social networks have on diverse nutrient management practice use and how contextual factors of the farm family shape overall conservation practice adoption.

The overall study population for this research was Iowa farmers who primarily grow corn and soybeans. The sample of farmers differed for each paper. This is so that we could better address each research question with an appropriate research design. The thesis as a whole draws on the diffusion of innovations theory and complex adaptive systems theory to assist in understanding the contextual factors that shape behavior as well as the process through which information travels through social networks.

The first paper seeks to investigate the impact social networks have on the adoption of diverse conservation practices among the general population of corn and soybean farmers in Iowa. The objective in this paper is to explore the potential social networks have in affecting nutrient reduction behavior. This paper seeks to answer the question: “What are the social network factors that are associated a diversity in the nutrient management practices used by farmers?” The data used for this study was from the 2012 Iowa Farm and Rural Life Poll

(IFRLP). This is an annual survey distributed to approximately 2,000 farmers that asks questions pertaining to agricultural policies, land stewardship, quality of life in rural Iowa, and other topics. Portions of the 2012 IFRLP asked farmers questions about information sources for nutrient management, general nutrient management practice use, and farmer perspectives on nutrient management strategies. This paper used ordinary least squares multiple regression modelling to investigate the different social explanatory variables that may be related to the diversity in the adoption of nutrient management practices.

The second paper addresses the social and contextual factors that are associated with conservation practice adoption. The objective of this paper is to discover how exemplary stewards of the land manage environmental goals for their farm operation while remaining profitable. The sample of Iowa farmers used for this portion of the study was drawn from the Iowa Farm Environmental Leadership Award program (IFELA). Qualitative interviews with a sample of 28 Environmental Leadership Award recipients were conducted over the summer and fall of 2014. This paper seeks to answer the question, "How do farmers who are recognized as exemplary stewards build resilient farming operations?"

The thesis is organized as follows. Chapter 2 investigates the relationship between social networks and the adoption of diverse conservation practices among general corn and soybean farmers in Iowa. Chapter 3 examines the social and contextual factors that shape Iowa farm families who are considered exemplary stewards of the land. Both chapters use diffusion of innovations theory and complex adaptive systems theory in a combined framework to examine the relationship between institutional structures and agency in the adoption-decision process of nutrient management practices. Chapter 4 presents a summary of overall empirical findings, conclusion, and suggestions for future research.

This research project was funded by the Iowa Nutrient Research Center. Established in spring 2013, the objective of this entity is to pursue science-based approaches that bridge socioeconomic and natural science research to assess the effectiveness of current and developing nutrient management practices as well as provide recommendations on practice implementation. Data analysis was conducted by Hanna Rosman, a graduate student at Iowa State University under the advisement of J. Gordon Arbuckle Jr., Associate Professor in the Department of Sociology at Iowa State University.

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CHAPTER 2

UNDERSTANDING THE DIVERSITY IN NUTRIENT MANAGEMENT PRACTICE USE IN MIDWESTERN AGRICULTURE

A paper to be submitted to *The Journal of Soil and Water Conservation*

Hanna Rosman and J. Gordon Arbuckle Jr.

Abstract

Over the last several decades, the negative effects of nitrogen and phosphorus pollution on aquatic and marine ecosystems have been increasingly well-documented. Nutrient fertilizers run off of farm fields, enter regional waterways in the Mississippi River Basin, and ultimately accumulate in the Gulf of Mexico. An assortment of nutrient management practices, such as fertilizer placement and timing, planting cover crops, and variable rate application methods can be used by farmers to reduce the amount of nutrients leaving farm fields. Biophysical research indicates that the inclusion of many different nutrient management practices is necessary to meet nutrient reduction goals established for the Gulf of Mexico region. Social science research has shown that a variety of information and social networks can influence practice adoption, but studies have generally focused on single practices or similar practices. In this paper, we ask: “What is the relationship between social networks and the diversity in nutrient management practices used by farmers?”

Data from the 2012 Iowa Farm and Rural Life Poll was used to answer the above research question. This study used ordinary least squares regression organized through the theoretical lens of the diffusion of innovations theory and complex adaptive systems theory to analyze selected variables. Results indicated that farmers who prefer face-to-face formats for receiving nutrient reduction information or are involved in farm organizations tended to use

more diverse nutrient management practices. Farmers who saw themselves as opinion leaders in their local communities also tended to use more diverse nutrient management practices. Discussions on future research directions included.

Introduction

Over the last several decades, the negative effects of nitrogen and phosphorus pollution on aquatic and marine ecosystems have been increasingly well-documented. Nitrates leaching from agricultural production systems are identified as the primary cause for the increasing concentrations of nutrient pollution in water systems around the world (Di and Cameron 2002). In the U.S Midwest region, a significant percentage of nutrient pollution entering waterways comes from diffuse, or nonpoint, agricultural sources. Nutrients from agriculture impair local waters and contribute substantially to the hypoxic or “dead zone” in the Gulf of Mexico, which leads to damaged marine life, and a decline in fisheries in the Gulf (Diaz and Rosenberg 2008, Boesch et al. 2009; Rabotyagov et al. 2014).

Researchers argue that it is the rise in pressure to meet global food, fuel, and fiber demands that threaten natural ecosystems and public health (Tilman 1999, Tilman et al. 2002; Robertson and Swinton 2005). Yield maximization is prioritized within agriculture to meet demand, and so the practices to address ecosystem services, such as clean water, are largely inadequate within current farm management strategies (Robertson and Swinton 2005). The predominant Corn Belt agricultural systems in the Midwest are ecologically leaky systems that leach nitrogen and phosphorus into surrounding water systems. The ways nutrients leave farm fields include land runoff, precipitation, atmospheric deposition, seepage, and hydrologic modification (ISU 2012).

Iowa is one of many major farming states in the Mississippi River Basin that contributes to Gulf of Mexico hypoxia. In 2013, the State of Iowa released a Nutrient Reduction Strategy (NRS) to establish goals to reduce the amount of nutrients entering waterways to address these ecological impairments. This plan was encouraged by the 2008 Gulf Hypoxia Action Plan, which called for states to develop strategies to meet the overall goal of at least a 45 percent reduction in the amount of nitrogen and phosphorus that enters the Gulf of Mexico (ISU 2012). Iowa established a statewide goal of a 41 percent reduction in nitrogen and 29 percent reduction in phosphorus (ISU 2012).

Diversity in Nutrient Management

A key objective of the Iowa strategy is to quantify the effectiveness of specific nutrient management practices and disseminate that science-based information to help farmers and their advisors make decisions about implementing practices to reduce nutrient losses (ISU 2012). A growing body of research indicates that significant reductions in nutrient loss will require the widespread adoption of diverse, agroecologically appropriate nutrient management and other conservation practices (Drinkwater and Sapp 2007, ISU 2012, Castellano and Helmers 2015; McLellan 2015). By quantifying the potential impact of practices and promoting numerous nutrient management practices and strategies, the NRS seeks to attain long-term water quality improvements (ISU 2012).

Most nutrient management adoption research has focused on a single practice (e.g., cover crops) or a collection of similar practices, such as conservation tillage (Prokopy et al. 2008). Few, if any, have attempted to understand the factors associated with the diversity in nutrient management practice use. Arbuckle and Rosman (2014) is one of the few studies to document diversity, but they did not examine the factors that may predict the diversity in nutrient management practice use. The growing recognition that widespread implementation of a *diversity* of practices is needed to attain nutrient reduction goals.

Social Networks and Conservation Practice Use

One of the few variables consistently found to be a predictor of conservation practice use (or non-use) is farmers' social networks (Prokopy et al. 2008). A social, or communication network, is the connection between individuals in a system who are linked by patterned information access (Rogers 2003). There is a predominant belief in research and technological development that innovations have the ability to sell themselves because of the advantages they offer (Rogers 2003), which may be true with purely economically profitable practices. Nutrient management practices are not purely economic practices, but environmental practices that provide ecosystem services to the public. For farmers, the adoption of conservation practices is a process rather than a discrete event centered on rational choices (Nowak and Korsching 1998). Prior research indicates there are non-economic or social factors at work in the diffusion of ideas and practices in agriculture (Ryan and Gross 1943, Rogers 2003, Rogers 2004).

The use of the diffusion of innovations theory as a guide to understand the role of social networks in conservation adoption research has documented the efficacy of information access and innovative individuals in increasing conservation practice adoption (Saltiel et al. 1994; Fuglie and Kascak 2001; Coughenour 2003; Pannell et al. 2006; McGuire et al. 2012). Nowak and Korsching (1998) argued that when considering soil and water conservation, it is important to gain a holistic understanding of the beliefs, motives, and actions of the farmer. The Iowa NRS is implemented on a voluntary basis, meaning farmers exercise their agency in the decision to implement nutrient reduction strategies. Although the Iowa strategy promotes a variety of nutrient reduction strategies that are effective, making progress towards the overall reduction goals has been stagnant (ISU 2012). Many within the scientific community have voiced that current program and outreach efforts by public agencies have not been successful in reaching farmers on soil erosion and water quality impairments (Nowak 2009). The current efforts focus on cost supports rather than activating farmer agency and orienting policy around participatory processes that may have positive effect on conservation adoption (Nowak 2009).

The ability for a farmer to adopt an array of conservation practices is dependent on the influence of other individuals and organizations. Nowak and Korsching (1998) argued, “All the good intentions of science and technology are meaningless until the farmer actually uses the practices” (p. 159). Identifying practices for effective outreach may lead to improved water quality outcomes. In this paper, we attempt to continue the line of inquiry into the role social networks play in conservation adoption. In this paper, we ask: “What is the relationship between social networks and the diversity in nutrient management practices used by farmers?”

We will first provide a brief summary of the theoretical framework that informs our study. Following this section is the literature review that summarizes the research on farmer use of nutrient management practices. Next, we will outline the methods and regression model used for analysis. This section will include descriptive statistics of the variables included in the study and our hypotheses. Following this section we will present the results of the regression model followed by concluding remarks and discussion.

Theoretical Framework

In this study, we use the diffusion of innovations (DOI) theory and complex adaptive systems theory (CAS) to guide the analytical approach. DOI lends insight into how social actors in a network are dependent upon one another. CAS emphasizes the importance of diversity in both the social and natural system. Both theories emphasize the importance of adaptation and adoption for overall system resiliency (Rogers et al. 2005). Resilience is defined as the ability for a system to withstand change and maintain stability through adaptation (Adger 2000; Walker et al. 2004; Folke et al. 2004; Folke et al. 2010). Nowak and Korsching (1998) argued that there is a connection between society and ecology because the decisions farmers make have an effect on the agroecological health of the land. The recognition of the connection between these two systems has been slow to develop due to the prioritization of the natural sciences over the social sciences in conservation practice research and development (Nowak and Korsching 1998) – thus decoupling two interrelated systems. The social world farmers navigate and the decisions they make to adopt a diverse set of nutrient management practices affect the overall agroecological health of their farm and ecosystems downstream.

DOI and CAS state that different social actors within a system may come together because of a new innovation or idea based on a common goal (Rogers et al. 2005). For the social actors integrated within Iowa agriculture - information sources and individual farmers - a common goal is nutrient reduction. We used this combined framework to situate and justify our selection of explanatory variables below that focused on the interdependency and variety within social networks and opinion leadership.

A significant aspect of both CAS and DOI is that critical mass is eventually reached when numerous individuals adopt a practice. At this point it is no longer an individual activity, but a system activity resulting in self-sustaining practices (Rogers et al. 2005). Understanding the outreach and promotional factors in farmers' social network may explain the adoption of diverse nutrient management practice use. This paper will explore two different categories of explanatory variables. These categories are information sources and self-designated opinion leadership. These categories will be further discussed in the methods section.

Social Networks and the Use of Nutrient Management Practices

While there has been a significant amount of research conducted on the adoption of conservation practices, the understanding of the factors that can predict diverse nutrient management practice use is limited. Suggestions from the literature include a focus on education and social networks in understanding conservation practice adoption (Prokopy et al. 2008). Because of this assessment by prior researchers, examining the association between social relationships and diverse nutrient management practice use may be crucial in determining the best means to achieve water quality goals.

In research by Osmond et al. (2014), the authors underscore that programs and policies should pay more attention to social and cultural influences in nutrient management practice adoption. In the study, the researchers examined a series of factors previously found to affect conservation practice adoption. These factors were: farm business (i.e. profit, yield, production costs), conservation efficacy (i.e. on and off site results of conservation efforts), and governmental relationships and approaches (i.e. attention from experts, networking, and trust) (Osmond et al. 2014). A key finding by Osmond et al. (2014) is that when extension services were used and had adequate resources, they were found to be effective in spurring adoption (Osmond et al. 2014). Extension efforts included improving the management of conservation practices as well as actively and consistently working with the same group of farmers (Osmond et al. 2014). Farmers from the study frequently viewed university recommendations for fertilizer application with uncertainty, and often opted to use recommendations from private dealers (Osmond et al. 2014). Overall the researchers recommend improving the lines of communication between farmers and education/technical support services as a way to increase nutrient management practice adoption (Osmond et al. 2014).

Weber and McCann (2015) also emphasized the role social networks play in nutrient management practice adoption. Their research examined potential predictors in the use of N soil testing, plant tissue testing, and N transformation inhibitors (Weber and McCann 2015). The authors found that these practices were not widely used by corn farmers even though they have great potential for reducing nutrient loss. Their research examined an array of farm and farmer demographic variables as well as social network variables as predictors of conservation practice use. These variables were education and information sources, location and farm size, and practices and technology (Weber and McCann 2015). There were mixed results in conservation practice adoption when examining specific information sources. The information sources included in the study were: extension agents, contractors, crop consultants, fertilizer dealers, and those who received no recommendations (Weber and McCann 2015). All of the conservation practices in the study were likely to be implemented by farmers who received nitrogen fertilizer recommendations from a consultant when compared to farmers who did not receive nitrogen fertilizer recommendations (Weber and McCann 2015). For some practices, the relationship between specific information sources and the nutrient management practice was not significant, such as for nitrogen transformation inhibitors (Weber and McCann 2015). For other practices, such as nitrogen soil testing, it had positive significant results when associated with some, but not all information sources. The researchers concluded that educational efforts to increase nutrient management adoption need to be tailored based on the farmer and the technology being promoted (Weber and McCann 2015).

Tamini (2011) investigated the factors that affect farmers' involvement in agri-environmental advisory clubs and the adoption of best management practices in Quebec. The purpose of this study was to pinpoint how involvement in agri-environmental extension activities affects the implementation of best management practices relative to non-participation (Tamini 2011). The study compared vertical linkages of information through extension services versus horizontal diffusion effects through farmers (Tamini 2011). The practices included in the study were: manure analyses, conservation tillage, immediate incorporation of manure, riparian buffer, non-use of mineral fertilizers, and hydraulic infrastructures (Tamini 2011). Results showed that for most of the practices in the study, extension participation (via vertical linkages) had significant results and a positive impact on the likelihood of conservation practice adoption (Tamini 2011). When examining horizontal diffusion effects among farmers, only three best management practices were found to be positive and significant. Tamini (2011) concluded that the social factors associated with BMP adoption are practice specific.

In summary, the research on nutrient management practices finds that social networks are important. One conclusion that can be drawn from the literature is that receiving recommendations from information sources in farmers' social network is important to enabling the adoption process for nutrient management practices (Osmond et al. 2014; Weber and McCann 2015; Tamini 2011). Not only this, but extension services may have a key role in conservation adoption (Osmond et al. 2014; Tamini 2011). However, the above research has focused on discrete practices or a collection of similar practices with mixed results.

Diversity is a key factor in reaching water quality goals outlined in the Iowa NRS. Significant reductions in nutrient loss depend on widespread adoption of diverse nutrient management practices and other conservation practices that are appropriate to local agroecology. Rogers (2003) argued that some innovations may only be appropriate for one individual, but detrimental or may not produce the same outcomes for another. The focus on the factors related to discrete conservation practices does not recognize how farm operations are situated in varying agroecological landscapes. The application of many nutrient management practices is dependent on landscape type and local hydrological factors (Haycock and Muscott 1995). Common practices that are landscape specific are yield goals, manure application rates, and barriers to nutrient loss such as riparian buffers. As a result, our scientific inquiry seeks to understand the relationship between social network factors and the use of diverse nutrient management practices.

Methods

The data for this study was collected through the 2012 Iowa Farm and Rural Life Poll (IFRLP), a statewide survey conducted on an annual basis through Iowa State University Extension. The 2012 survey was mailed to 2,219 farmers in February 2012. Surveys were received from 1,296 farmers, for a 58 percent response rate. Because our interest is in the use of nutrient management practices, we limit our analysis to the 996 respondents who planted corn and soybean in 2011, and for whom nutrient management is most relevant.

We employed ordinary least squares regression modelling to examine the relationships between our dependent variable—nutrient management practice diversity —and selected predictor variables. Further, we used a hierarchical regression approach that entered explanatory variables into the model in groups to better understand their relative importance as predictors. Hierarchical regression is an approach in which predictors are chosen and organized in the model based on prior understandings of the variables (Field 2013). This approach can be preferable to standard multiple regression when researchers wish to understand the impact that different sets of explanatory variables have on the dependent variable. Based on our review of the literature and our theoretical framework, we chose to enter the variables related to farmers' information sources into the model first, followed by the opinion leadership variable. The variables used in this study for each theoretical component and our rationale for their inclusion will be described in greater detail below.

Dependent Variable

Nutrient Management Practice Diversity

The full scope of nutrient management practices available to farmers include a wide range of practices that are older, such as crop rotations, and newer, more innovative practices such as canopy sensors. Rogers (2003) argued that research that focuses on innovations as independent entities represents an oversimplification. That is, it assumes the adoption of one practice is similar to the adoption of another. Attention should be focused on "technology clusters," which are a series of distinct elements of a technology that address a common outcome (Rogers 2003).

The dependent variable was an index measuring diversity in nutrient management practice use. This was the number of practices farmers use to manage nitrogen in their farm operations. Farmers were presented with a list of 18 practices used to manage nitrogen (Table 1). The list, which contained both commonly used and newer, innovative best management practices (BMPs), was developed in consultation with ISU Extension field agronomists and soil scientists who work with farmers and conduct research on the effectiveness of different practices. Farmers were presented with 5 options to select to indicate their level of use for each of the nutrient management practices. These options were: not familiar with; familiar with, but do not use; limited use; moderate use; and heavy use.

Table 1. Farmers' use of practices to manage nitrogen.

			Do Not Use	Limited Use	Moderate Use	Heavy Use
	Mean	**Std. Dev.**	*-- Percentage --*			
Nitrogen Management Practice	**32.58**	**7.04**				
Soil Testing			13.5	20.3	39.5	26.7
Crop Rotations			4.6	9.7	35.4	50.4
Animal Manure			39.1	21.6	23.2	16.1
Plant Legumes			44.3	25.0	21.0	9.7
Yield goals			10.4	16.7	43.8	29.2
Late spring nitrogen test			70.2	19.9	6.8	3.1
Integrated Crop Management			59.8	22.8	13.4	3.9
Variable fertilizer rate			40.8	23.2	22.5	13.4
Test Strips			61.2	24.2	9.7	4.9
Stalk N Tests			72.1	17.5	6.2	4.1
Soil Temperatures			37.5	26.8	25.2	10.6
Aerial photos or remote sensing			75.3	14.8	7.6	2.2
Canopy sensors for nitrogen deficiency			92.8	4.8	2.1	0.3
Corn N Rate Calculator (MRTN)			78.1	12.0	7.6	2.3
Nitrification Inhibitor (e.g., N-Serve)			60.5	15.2	13.8	10.6
Urease Inhibitor (e.g., Agrotrain)			81.1	9.9	5.5	3.5
Coated Urea (e.g.s, ESN)			83.1	10.4	4.6	1.9
Cover Crops			71.1	18.4	8.1	2.4

For analysis the options "not familiar with" and "familiar with, but do not use" were combined into one category labelled "do not use." This is because we only sought to measure the level of use, rather than both use of and familiarity with a nutrient management practice. For our model, the index was created by creating a summative scale of the practices in Table 1. The potential numerical values for the practices ranged from 18-72.

Normality tests for this summative scale indicated slight kurtosis (1.69) and a skewness of 0.164, making the data not normally distributed and violating the assumptions needed for the regression model. For data to be normally distributed, the data should have a kurtosis and skewness value near zero (Field 2013). Further analysis showed there were two cases that were extreme outliers with values above 66 and unlikely to be true. These two cases were removed from the sample, resulting in a kurtosis of 0.622 and skewness of 0.164. After outlier removal, the mean score of diverse nutrient management practice use among the sample was 32.58 and had a standard deviation of 7.04.

Independent Variables

Information Sources

Farmers are largely considered to be adapters due to ever-changing commodity prices, the price of inputs, weather, and the agroecological health of their farm operation. Access to and the understanding of how components in the social-ecological system function is important for an individual to be able to maintain resilience (Folke et al. 2002). An information source is an individual or an institution that a message originates from (Rogers 2003). Information sources, such as private sector salesmen, universities, extension services, and farm and organizations, link individuals to research and development that is created outside the system that farmers reside in (Rogers 2003). This makes the farmers' ties to information sources and how they disseminate information conditional on the sources they turn to. We included four variables relating to information sources in the model.

Preferred ways of receiving nutrient management information

The process of the adoption of a practice begins with an individual acquiring knowledge. Some of the ways knowledge can be acquired is through an established connection an individual has with an information source or through an individual initiating contact (Rogers 2003). That is, the individual is actively engaging with a resource rather than passively receiving information. Rogers (2003) argued that the disposition of the individual affects the impact that messages may have. This means that an individual's preference for how they receive information may have an impact on the effect the messages have on the individual. Findings show that digital formats for information are gaining traction among farmer audiences, but face-to-face communication channels are still key ways to reach farmers (Tucker and Napier 2002).

The 2012 IFRLP asked farmers to indicate their preferred ways to receive nutrient management information and education programs from Iowa State University Extension (Table 2). Farmers were presented with the following text:

> Iowa State University Extension delivers information and educational programs in many ways. Please indicate which would be preferred ways for you to receive information and educational programs from Extension on the following topics.

Farmers were then presented with six potential formats—field days; workshops, trainings, meetings; online videos, webcasts; downloaded publications; "Apps" for a Smartphone; would probably not use Extension; and not applicable—and asked to select all that applied. For this study, we are interested in the relationship between preference for in-person programming on nutrient management and diversity of practice use. Thus, a scale variable was created measuring farmer preference to receive information on "nutrient management" and "fertilizer application rate" in field days or in workshops, trainings, and meetings (Face2Face).

The variable was created by counting the number of times farmers indicated that they would prefer field days or workshops, trainings, and meetings for either nutrient management or fertilizer application rate information. A zero on the scale means that farmers indicated that would not prefer either of the face-to-face formats to receive information on either nutrient management or fertilizer application rate information. A four on the scale means that farmers indicated that they would prefer the face-to-face formats for both nutrient management and fertilizer rate application information. Face2Face had a mean of 1.25 and a standard deviation of 1.19. Based on the literature and our theoretical framework, we expect the relationship between farmers who prefer face-to-face formats to receive information to be a positive in relation to diverse nutrient management practice use.

Table 2. Farmers' preferred ways to receive information and educational programs on nutrient management and fertilizer application rate from Iowa State University Extension.

	Field Days	Workshops, Trainings, Meetings	Online Videos, Webcasts	Downloaded Publications	"Apps" for a Smartphone or Tablet	Would probably not use Extension
	-- Percentage --					
Nutrient Management	24.5	40.7	13.3	20.1	2.9	12.9
Fertilizer Application Rate	24.3	35	10	20.9	2.5	16.6

Preferred sources of information

Farmers have an array of information sources available to them to receive information. These sources represent different types of knowledge that farmers can receive on nutrient management practices. Rogers (2003) states there are three types of knowledge about an innovation: awareness-knowledge, how-to knowledge, and principles-knowledge. Awareness-knowledge is the acknowledgement that an innovation is available while how-to knowledge is the provision of information available to use an innovation correctly (Rogers 2003). The information sources available in farmers' social network that may capture these types of knowledge are private sector sources. This is because the function of these sources is to provide farmers with the crop production inputs and the directions for how to use them. Principles-knowledge is information consisting of the principles that underpin how an innovation works (Rogers 2003). Public sector sources of information in farmers' networks emphasize this type of knowledge alongside how-to knowledge. This is because the function of these resources is not only to share information with farmers, but also to emphasize how nutrient management practices work to improve soil health and improve water quality impacts (e.g. NRCS 2001).

Individuals usually have the ability to adopt a practice without principles-knowledge and can rely on how-to knowledge to determine its effectiveness (Rogers 2003). Individuals also tend to expose themselves to ideas and innovations in relation to existing needs, interests, and attitudes (Rogers 2003), which largely characterizes the sources of information that individuals rely on. Studies show farmers' identity ranges on a spectrum between crop producers and stewards of the land (McGuire et al. 2012). With this theoretical perspective, individuals tend to consult information sources that are consistent with how they identify themselves within the system.

Research on the impacts of private sector sources on water and soil quality information has mixed results. Some argue that in sustainable land management, private sector sources operate within a profit maximization system that is oriented around pushing the use of more products to farmers rather than less (Ward 1995), thus having a negative impact on water and soil quality. Counter to this, studies throughout the 1990s have shown that farmers do consult private sector sources on soil and water conservation (Bruening and Martin 1992, Tucker and Napier 2002). A study by Ingram (2008) shows private sector sources cannot be considered a homogenous group. Some relationships between private sector advisors and farmers have an imbalance of power, but other relationships between these social actors facilitate education in conservation practice adoption (Ingram 2008).

Private sector sources are often charged with balancing farmer interests, needs, and management problems to keep loyal customers (Ingram 2008). Findings show that an expanding demand from the farmer-level for conservation may encourage private companies to have a greater involvement in conservation practice adoption (Coughenour 2003, Ingram 2008). This is especially relevant given the Iowa NRS is becoming more pervasive at the farmer-level with the phrase “voluntary, but not optional” popularly included in the rhetoric on nutrient management (Eller 2013). Farmers who are interested in conservation adoption balance production goals with agroecological outcomes on their farms. Based on the above literature and theoretical perspective, the relationship between all of the above information sources and diverse nutrient management practice use is expected to be positive.

In the 2012 IFRLP, farmers were asked to indicate where they go first for information on nutrient management and fertilizer application rates. Farmers were presented with a list of public and private information sources. The public sources were: the United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS), Soil and Water Conservation District Service Center (SWCD Service Center), and Iowa State University. Private sources of information were: Fertilizer or Ag Chemical Dealer, Seed Dealer, and Private Crop Consultant. We organized these information sources into two categories. One category was “public resources first for nutrient management” (PubFirstNM). The other category was “private sector first for nutrient management” (PrivSctFirstNM). Both variables are on a 3-point scale to indicate where farmers go first for information (Table 3). A zero on the scale means that farmers would not turn to the information source for information on either nutrient management or fertilizer application rate. A two on the scale means that farmers would turn to the source for information on both nutrient management and fertilizer application rate. PubFirstNM had a mean of 0.29 and standard deviation of 0.58. PrivSctFirstNM had a mean of 1.65 and a standard deviation of 0.64.

Table 3. Information sources farmers turn to first for Nutrient Management and Fertilizer Application Rate

	Private source first	Public source first
	-- Percentage --	
Zero	10.9	77.9
One	17.3	15.2
Two	71.8	6.9

Involvement in agricultural and natural resource organizations

Innovations have the ability to be adopted by organizations of individuals. An organization is a collection of individuals who work together for a common goal (Rogers 2003). Within the agriculture industry, farm organizations have played a historical role in the political representation of farmers (Clemens 1997). Farm organizations have grown to serve many purposes for farmers, including education and technical services for nutrient management practices. Rogers (2003) argued that organizations have the ability to coordinate large scale endeavors due to their stability and "organizational innovation." Organizational structures that are conducive to innovation adoption contain charismatic leaders as well as measures of decentralization, complexity, interconnectivity, and undedicated resources available for multiple purposes within the organization (Rogers 2003). Centered on this understanding, the relationship between farm organizations and diverse nutrient management practice use is expected to be positive.

The 2012 IFRLP asked farmers to indicate their level of involvement in agriculture and natural resource conservation organizations, such as the Iowa Soybean Association and Practical Farmers of Iowa. This variable was on a 5-point scale to measure farmers' level of participation (1 = Have Never Been a Member" to 5 = Very Active) in Table 4. For this paper we combined the agriculture and natural resource conservation organizations into a summative scale to index farmers' overall involvement in these organizations. The summative scale was used to determine the association between organization involvement and diversity in nutrient management practice use (AllOrgInvlv). The scale for AllOrgInvlv ranged from 10-50 with an average of 15.03 and a standard deviation of 3.61.

Table 4. Mean, standard deviation, and percentage distributions for farmer involvement in Agriculture and Natural Resource Conservation Organizations

	Mean	Std. Dev.	Have Never Been a Member	Was a Member, But Not Now	Member, not Active Participant	Active	Very Active
Farm Organization	**15.03**	**3.61**	*-- Percentage --*				
Iowa Farm Bureau Federation			18.8	17.5	49.6	11.0	3.1
Iowa Farmers Union			94.4	2.7	2.4	0.3	0.2
Iowa Corn Growers Association			50.9	13.3	30.1	5.0	0.6
Iowa Soybean Association			46.2	13.0	35.3	4.9	0.6
Iowa Pork Producers Association			63.4	26.4	7.1	2.4	0.7
Iowa Cattlemen's Association			66.6	18.4	9.5	4.2	1.2
Practical Farmers of Iowa			94.5	3.1	1.5	0.5	0.3
Iowa Organic Association			97.5	1.4	0.5	0.3	0.2
Iowa Natural Heritage Foundation			94.6	2.8	2.3	0.3	0.1
Iowa Environmental Council			97.7	1.1	0.8	0.2	0.1

Opinion Leaders

Leadership within local agriculture communities has been shown to have an impact on conservation practice adoption (McGuire et al. 2012; Coughenour 2003). Rogers (2003) states that opinion leadership is the degree an individual can influence others' attitudes and behaviors towards a desired outcome. The status of an opinion leader is not a formal position, but earned and maintained through expertise, accessibility, and conformity to the social system (Rogers 2003). Opinion leaders have relatively high exposure to information from outside the system, but they also tend to be the center of local communication networks (Rogers 2003). In this light, opinion leaders have a dual role of fulfilling what is expected of them as well as exert influence on others to change their practices. Rogers et al. (2005) state that in a DOI and CAS framework, "networks allow the system to solve problems using the large numbers of individual nodes that have local interactions with other nodes" (10). Individuals learn from one another through observation of an opinion leader and then seek to try out practices themselves through the dynamic nature of feedback processes (Rogers et al. 2005). Overall, opinion leaders may be a critical aspect of the system because s/he has the power to affect others.

Although DOI illuminates the potential role opinion leaders have in the diffusion of innovations within a social system, there has been little exploration of this concept in conservation adoption research. Rather, more is known about the explanatory power that information sources have in discrete and collective conservation practice adoption studies (Prokopy et al. 2008). A case study by Coughenour (2003) showed adoption of no-till farming that began with a few key opinion leaders who were central to the farming network in a Kentucky county. One of the opinion leaders was a county extension agent who was a part of the local culture but also had expertise in conservation (Coughenour 2003). Not only this, but his personality was described to have enthusiasm that "gave an infectious quality to his advocacy of no-tillage" that created a communication channel to skeptical farmers on conservation practice adoption (Coughenour 2003, p. 290). Findings from this study show that through local interaction, opinion leaders may have the ability to construct new meanings and approaches to farming that incorporate conservation (Coughenour 2003). Having key social actors in an agriculture community who have a common background with others, but expertise in conservation, eased the adoption diffusion process of no-till. Based on the literature available and our theoretical framework, we expect the relationship between opinion leadership and diverse nutrient management practice use to be positive.

The 2012 IFRLP contained seven statements measuring dimensions of the latent construct of "opinion leadership." Farmers were asked to consider statements, which were self-evaluations of their position in local social networks, interaction with information sources, and standing in the local agriculture community, and then rate their agreement or disagreement on a five-point scale (strongly disagree = 1 to strongly agree = 5). The statements and their percentage distributions are presented in Table 5. These statements were combined into a summative scale that measured opinion leadership among farmers. The summative scale for the items, labelled "OpinionLdr" has a Cronbach's alpha reliability coefficient of 0.867. This demonstrates a high level of internal consistency in measuring the same latent variable, which is the social construct of self-designated opinion leadership in farming communities. The scale ranges from 6 to 35, with a mean of 19.32 and a standard deviation of 4.56.

Table 5. Mean, standard deviation and percentage distributions for opinion leadership among farmers.

Variable Name	Mean	Std. Dev.	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
OpinionLdr scale	**19.32**	**4.56**	*-- Percentage --*				
It is important to me to keep up with the latest farm management practices and strategies			1.3	6.5	12.4	62.4	17.4
Other farmers tend to look to me for advice			7.3	33.2	42.1	15.9	1.5
I consider myself to be a role model for other farmers			7.4	32.9	41.9	16.6	1.1
Extension staff, crop advisers, and others involved in agriculture end to look to me for advice			18.0	51.6	25.4	4.8	0.2
I take a leadership role in local agricultural matters			15.8	49.9	22.4	11.0	0.8
Compared to other farmers, I tend to use more innovative management practices and strategies			8.7	33.3	33.4	21.5	3.2
My opinions matter in the local agricultural community			13.6	30.2	37.9	17.1	1.2

Corn and Soybean Production

Because the nutrient management practices that form the diversity index are primarily relevant to corn and soybean farmers, we include a measure of magnitude of corn and soybean production to control for the relationship between this variable and diversity of nutrient management practices. The variable measures number of acres planted to corn and/or soybean in 2011 (CornSoyTotalAc). The average amount of acres farmers had in corn and soybeans in the 2012 IFRLP was 441 acres.

Study Hypotheses

1. Farmers who prefer to receive nutrient management information in face-to-face settings will use more diverse nutrient management practices.
2. Farmers who indicate that they go to extension/public sources first for nutrient management information will use more diverse nutrient management practices.
3. Farmers who indicate that they go to private sector sources first for nutrient management information will use more diverse nutrient management practices.
4. Farmers who are more involved in agriculture and natural resource conservation organizations will use more diverse nutrient management practices.
5. Farmers who rank themselves high on the opinion leadership index will use more diverse nutrient management practices.

Results

Table 6 shows the estimated ordinary least squares regression function. It presents nutrient management practice diversity as the dependent variable and factors related to social networks as explanatory variables. The table is organized by the hierarchical regression groups that were entered into the model. The overall outcome of the regression analysis showed the extent to which the predictor variables explain diversity in nutrient management practice use. The results showed that 27 percent of the variation in the diversity of nutrient management practice use is explained by the explanatory variables in the model. The results of the model were consistent with previous studies that showed that social networks among farmers have a positive association with an increased use in nutrient management practices.

Table 6. OLS Regression of social network variables predicting the diversity in nutrient management practice use.

	Diversity in Nutrient Management Use (Dependent Variable)											
	Model 1				Model 2				Model 3			
(Predictor Variables)	B	Std. Error	Std. Beta	Sig.	B	Std. Error	Std. Beta	Sig.	B	Std. Error	Std. Beta	Sig.
Information Sources												
Face2Face	.626	.192	.106	.001	.293	.180	.050	.104	.369	.180	.062	.040*
PubFirstNM	1.181	.797	.098	.139	.751	.740	.062	.311	.624	.734	.052	.395
PrivSectFirstNM	.015	.723	.001	.984	.128	.671	.012	.849	.021	.665	.002	.975
AllOrgInvlv	.619	.063	.317	.000	.359	.063	.184	.000	.313	.063	.160	.000***
Opinion Leadership												
OpLdrScale					.593	.050	.384	.000	.541	.051	.351	.000***
Other												
CornSoyTotalAc									.002	.000	.129	.000***
Adjusted R Square (cumulative)	.132				.254				.267			
F	33.59***				59.06***				52.91***			
n	855				855				855			

* p ≤ .05 **p≤.01 ***p ≤ .001

Information Sources

Overall, 13 percent of the variance in the diversity in nutrient management practice use was explained by the preference for and use of different information sources. Some of the covariates in the model examining information sources in this model were significant and positively associated with the explanatory variable. The coefficient for Face2Face is positive, which indicated that the preference to learn about nutrient management through ISU Extension field days, meetings, and workshops is associated with more diverse nutrient management practice use. This result supported the first hypothesis. PubFirstNM was not found to be significant. This means that we failed to reject the null hypothesis, and so there was no statistically significant relationship between turning to public sector sources first for nutrient management information and diverse nutrient management practice use. PrivSectFirstNM was also not found to be significant. Our findings indicated there was no statistically significant relationship between turning to private sector actors first for nutrient management information and diverse nutrient management practice use. These findings do not support the second or third hypotheses. The variable, AllOrgInvlv, had a positive coefficient in association with the dependent variable. This indicated that farmers who are more involved in agriculture and natural resource conservation organizations use more diverse nutrient management practices than those who are not. This supported our fourth hypothesis in the study.

Opinion Leaders

Overall, 12 percent of the variance in the model was explained by opinion leadership. This is a significant finding given lack of scientific inquiry into the association between opinion leadership and conservation practice adoption. OpLdrScale was found to be a significant and positive predictor of diverse nutrient management practice use. This indicated that farmers who ranked themselves high on the opinion leadership index used more diverse nutrient management practices. This result supported our fifth hypothesis.

Corn and Soybean Production

In the model, 1 percent of the variance in nutrient management practice use was explained by the magnitude of corn and soybean production. CornSoyTotalAc was found to be a significant and positive predictor of diverse nutrient management practice use. This indicated that the more acres farmers have in corn and soybean production the more diverse nutrient management practices they use on those farm acres.

Discussion and Conclusion

The results of the OLS regression analysis generally supported our hypotheses. The purpose of this research was to examine relationships between key elements of farmers' social networks and their use of diverse nutrient management practices. A hierarchical approach to this data allowed us to begin to understand the importance of different social network factors on diverse nutrient management practice adoption. Other studies recommend extension as a key predictor for the adoption of discrete practices. These results in respect to diverse nutrient management practice use suggest otherwise. Overall, biophysical scientists find that to make serious strides towards nutrient reduction, multiple and diverse nutrient management practices must be incorporated into farming operations. Our attempt at examining the relationship between social networks and diverse nutrient management practice use shows many social factors may lead to greater improvements in nutrient loss and meeting the goals outlined in the Iowa strategy. In our examination of information sources, we found that some variables we used were good predictors of diverse nutrient management practice use. This supports previous studies that examined soil and water conservation information sources (Tucker and Napier 2002, Weber and McCann 2015).

The relative importance of the preference for face-to-face contact for nutrient management in association with diverse nutrient management practice use is consistent with other studies (Tucker and Napier 2002). . Farmers have the ability to engage with nutrient management information through both active (i.e. field days) and passive formats (i.e. digital publications). Our study shows the preference for face-to-face, or more active formats has a positive relationship with diverse nutrient management practice use. In examination of this variable, the rate of speed in how farmers are receiving and engaging with information on nutrient management may affect the adoption of diverse nutrient management practices. Although the reception of information may be fast through online media, the ability for individuals to respond to these resources may be slow. Feedback processes may be crucial to decision-making and adoption (Rogers et al. 2005). Quality may also be preferential to quantity in information delivery. Informational formats that are less frequent, but evaluated to be more credible may have a higher impact on adoption decisions (Tucker and Napier 2002, see also Kromm and White 1991). Face-to-face contact through formats such as field days and workshops may be an effective way to reach the current population of farmers on diverse nutrient management practice use.

In respect to the information sources that farmers turn to first for nutrient management information, our findings show no statistically significant relationships between different informational sources (private sector sources and public sector sources) and diverse nutrient management practice use. A possible explanation for the lack of relationship between the variables could be that the question in the 2012 IFRLP examining the information sources farmers go to first for information on nutrient management was not a robust enough measure of information source use. The survey only asked farmers to indicate which sources they would turn to first for information. More robust measures might ask farmers to rank the informational sources they turn to for nutrient management information or to rank the influence different informational sources have on their use of nutrient management practices.

Our findings also show that involvement in agriculture and natural resource organizations is positively related to diverse nutrient management practice use. This supports the concepts within our theoretical framework that organizations can shape efforts towards a common goal, such as improving water quality. Organizations have the ability to provide structure, but allow for a measure of openness among its members to enable the diffusion of ideas and practices (Rogers 2003). Farm organizations consist of leaders and internal networks of farmers and professionals. In organizations such as the Iowa Soybean Association, working towards a collective goal, such as mitigating nutrient loss, strengthens the communication channels among its members. This organization has a program called the On Farm Network that brings scientific experts and farmers together to meet a desired organizational outcome, which is an improvement in water quality and soil fertility on farms (ISA 2013). The results of the model examining farm organization involvement suggest that similar interaction may occur within farm organizations in respect to diverse nutrient management practice use.

One of the most significant findings from the model is the relationship between opinion leadership and diverse nutrient management practice use. Our results are consistent with past studies on conservation practice adoption that involve local leaders who enable the adoption diffusion process (Coughenour 2003, McGuire et al. 2012). Although opinion leaders are conceptualized to play a significant role in the diffusion of innovations theory (Rogers 2003), few studies have sought to examine their role in conservation adoption. The results in our model support the need for researchers to pay more attention to opinion leaders and the influence they may have in nutrient management practice adoption.

A shortcoming of the study is that we did not include multiple measures of economic factors beyond farm size, such as gross farm income, land owned, and land rented by the farmers in this study. Because the recommendations from the literature emphasized the importance of social network factors in nutrient management practice adoption, our focus was only on the importance of social networks in association with diverse nutrient management practice adoption. Future research could include economic variables to understand how financial considerations overlap with the diffusion of information in conservation practice adoption.

Although there are a number of shortcomings, this study opens up the discussion on the need to bridge the relationship between social network factors and diverse nutrient management practice use. Farmers must be able to maintain resilient farm operations for the future, which means using an array of practices on their farms to improve productivity as well as mitigating negative environmental externalities. Some studies support that farm management technologies do not necessarily have the ability to sell themselves based on the relative advantage they offer to the farmer (Rogers 2003). Our findings indicate that innovation adoption may rest on the "sellers" or information sources themselves to propagate the use of a diverse range of conservation practices. To achieve the goals of the Iowa Nutrient Reduction Strategy, it is necessary to advance the research to reflect how Iowa farmers navigate decision-making and choose to adopt a diverse range of nutrient management practices.

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CHAPTER 3

DISCOVERING THE ROOTS OF IOWA FARM ENVIRONMENTAL LEADERSHIP

A paper to be submitted to *Agriculture and Human Values*

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Abstract

There is an increasing focus on the environmental costs of crop production in the U.S. Corn Belt. Research shows that a consequence of commodity crop production systems is nutrient loss and soil erosion that leads to impaired local waterways and the hypoxic zone in the Gulf of Mexico. As a response, in 2013, the State of Iowa released the Nutrient Reduction Strategy that outlines goals to reduce losses of nitrogen and phosphorus into waterways. Coinciding with this strategy the Iowa Farm Environmental Leadership Award program was started to recognize and publicize family farms that take extraordinary efforts to implement conservation practices on their farms. This research seeks to answer the question: "How do farmers who are recognized as exemplary stewards build resilient farming operations?"

Qualitative interviews with a sample of 28 Iowa Environmental Leadership Award recipients were conducted over the summer and fall of 2014. This study draws on the diffusion of innovations theory and complex adaptive systems theory to help understand the contextual factors that shape exemplary conservation behavior. Results from this study show that the family farm contextual factors and a stewardship ethic are significant in conservation adoption. This paper will explore these results and propose future research directions.

Introduction

There is an increasing focus on the environmental costs of crop production in the U.S. Corn Belt. Soil and water are the most basic resources to support crop production and ecological habitats (Blanco-Canqui and Lal 2008). In corn and soybean production, the short-term needs of commodity crops are prioritized over the long-term health of agroecosystems in land management (Magdoff et al. 1997). Often this means that more fertilizer is being used than actually needed at the detriment of soil and water quality (Magdoff et al. 1997). This draws significant concern in respect to the resilience of production agriculture for the future. In its current state, it is an inefficient system that has negative ecological impacts for soil and water which may have drastic implications for future production demands (Magdoff et al. 1997).

The impacts of nutrient loss on water quality and soil erosion have increasingly become visible over recent years. The evidence is seen from scientific assessments on U.S. Coastal Waters showing the economic and biological complexity of hypoxic zones (Interagency Working Group 2010). In the Midwest, significant amounts of nutrients, specifically nitrogen and phosphorus, leave farm fields and enter waterways leading to water impairments. There is evidence of increased undesired algae growth in the Gulf of Mexico as a result of the accumulation of nutrients from inflowing waterways (Diaz and Rosenberg 2008; Boesch et al. 2009). This nutrient accumulation creates algae blooms in aquatic environments that fail to support marine life, including commercially marketed fish species - thus the creation of the hypoxic or "dead" zone in the gulf (Rabotyagov et al. 2014).

As a response to ecological impairments and encouraged by the EPA 2008 Gulf Hypoxia Action Plan, the State of Iowa released a Nutrient Reduction Strategy (NRS) in 2013 to address both point sources and non-point sources of pollution. In Iowa, a majority of water pollution is due to the loss of nitrogen and phosphorus from agriculture, which move into off-farm environments through processes such as surface runoff, volatilization, atmospheric deposition, and agricultural drainage and other hydrologic modification (ISU 2012). In 2012, seventy-seven percent of rivers and streams were assessed as impaired in Iowa while only 22 percent of rivers and streams were designated as good (EPA 2012). Iowa's NRS has targeted a 41 percent reduction in total nitrogen loads and a 29 percent reduction in total phosphorus loads (ISU 2012). These goals are intended to support the overall Gulf Hypoxia Action plan goal of 45 percent reduction in both total nitrogen and phosphorus loads to the Gulf of Mexico (ISU 2012).

The Iowa NRS identifies several policies and programs to help farmers achieve reductions in nutrient losses from farm fields. These policies and programs include conservation outreach to farmers, the promotion and cost-share funding of effective in-field practices to mitigate runoff, watershed pilot projects, nutrient trading, and other innovative approaches (ISU 2012). Such approaches have formed the foundation of state and federal conservation policy and programming for the past several decades (Lambert et al. 2006). These programs, especially working lands programs, have raised participation in conservation programs (Claassen et al. 2003; Lambert et al. 2006). Although that is the case, the predominant conservation policy as a voluntary approach is criticized by the scientific community for not meeting goals in key areas, such as soil erosion and nutrient reduction (Knight 2005, Nowak 2009). This is due to the focus of these programs being largely oriented around financial supports rather than participatory processes and farmer agency in the adoption decision process of conservation (Nowak 2009).

One of the programs in support of the Iowa NRS that is centered on participatory processes is the Iowa Farm Environmental Leadership Award Program (IFELA). This program was started in 2012 to recognize and publicize family farms that take extraordinary efforts to implement conservation practices on their farms. The purpose of this program is to acknowledge farmers who have taken significant steps to improve and protect natural resources on their farms (IDALS 2014). The recipients of the award were chosen by a selection committee that represents state agricultural agencies as well as Iowa farm and natural resource organizations (IDALS 2014). The selection criteria for IFELA recipients is based on the conservation practices farmers incorporate into their farms and the conservation leadership positions they hold in their communities (IDALS 2014). An objective of the IFELA program is to encourage other farmers in Iowa to follow in the footsteps of the IFELA recipients and incorporate environmental stewardship into their farming operations (IDALS 2014). As a role model to other farmers, IFELA recipients may embody the characteristics and use practices that enable resilient agriculture in the Midwest.

Understanding how leaders in environmental stewardship attain exceptional levels of conservation may be important to gaining insight into how resilient agriculture can be achievable. We build on previous research by examining how these "farm environmental leaders" have implemented conservation on their farms to the extent that they have been recognized publicly as conservation role models. In this paper, we draw on qualitative research with IFELA recipients to examine the question: "How do farmers who are recognized as exemplary stewards build resilient farming operations?"

Research in Support of Agricultural Conservation

Research conducted in support of mainstream conservation programming has had shortcomings. Lockeretz (1990) argued that research is not predictive of conservation adoption because research is set up to be too narrow. Researchers often limit themselves to three schools of thought. These are: "economics is the main consideration, farmers adopt soil conservation according to the same pattern as other innovations… or that the adoption process is specific to innovations concerned with environmental quality rather than economic return" (Lockeretz 1990, p. 522). These schools of thought restrict academic inquiries into conservation adoption because they are narrow in focus, quantitative, and use easily obtainable data. These measures do not fully demonstrate the intensity that certain measures, such as years farming, may have on conservation adoption (Lockeretz 1990). Influential factors not captured by a limited research approach may include familial relationships, experiences, and historical events that may affect behavior. These current approaches gloss over the context that may help or hinder conservation adoption among farmers.

A major focus by prior research has been on variables such as farm characteristics, environmental awareness, and attitudes (Prokopy et al. 2008). A meta-analysis by Prokopy et al. (2008) shows that a selection of social factors may be associated with the adoption of conservation practices. These include education, information access, labor, capital, acres, and diversity (Prokopy et al. 2008). These are all factors that may bear a relationship to contextual factors that shape a farm operation. Overall, researchers may not be looking in the appropriate places, such as contextual factors external to the farmer in conservation adoption (Lockeretz 1990).

Suggested Pathways for Research on Conservation Decision-making

We follow up on several recommendations from researchers who have previously explored the adoption and diffusion of conservation practices. Studies conducted by scholars in the field have pointed to the importance of social networks and information sources in conservation practice adoption (Saltiel et al. 1994; Fuglie and Kascak 2001; Coughenour 2003; Pannell et al. 2006; McGuire et al. 2012). Prokopy et al. (2008) recommend that future research should look into whether it is the ability to access social networks or the effect of networks that shapes practice adoption. Reimer et al. (2014) states that social science should pay more attention to the influence social networks have on conservation adoption. They note that while social ties played a central role in the diffusion of innovations research in the past, contemporary research on conservation behavior has not focused sufficiently on the potential impacts of factors such as professional networks, social capital, and community culture on conservation behavior (Reimer et al. 2014).

Opinion leadership has traditionally been an important component of the diffusion of innovations tradition. Opinion leaders are considered to be models of exemplary behavior, for which others in their social networks can follow (Rogers 2003). Given the importance of opinion leadership in the DOI model, it is surprising that little conservation adoption research has attempted to examine the relationship between opinion leadership and conservation behavior. Some studies have examined leadership in the adoption of conservation practices through the lens of the DOI model (Coughenour 2003, McGuire et al. 2012). The results from these studies indicate that more research in this area is needed to understand the role opinion leaders play in conservation adoption.

The paper examines the factors that shape the conservation behavior of opinion leaders, in this case, Iowa Farm Environmental Leadership Award recipients. First, we will first present a brief overview of the theoretical framework that will guide our analysis. This will include a discussion on the theoretical perspectives we use for analysis as well as our literature review informing our analysis. Next, we will briefly summarize our conceptual model and research methods followed by the results and discussion section. We conclude this paper with a brief discussion of the significance of our findings in relation to future research directions.

Theoretical Framework

A theoretical framework for understanding conservation adoption on Iowa family farms needs to be broad enough to facilitate systematic, in-depth analysis of the many contextual factors that influence farmer decision-making, but specific enough to understand the effects on local agroecology.[1] We combine elements of the Diffusion of innovations (DOI) theory and Complex Adaptive Systems (CAS) theory to organize our research. DOI recognizes the interdependency of social networks in innovation adoption. CAS emphasizes heterogeneity and context as a means to enhance system resiliency (Rogers et al. 2005).

DOI focuses on how new information and innovative practices are spread within a population. This diffusion involves four elements: the innovation itself, communication channels, time, and the social system (Rogers 2003). The acceptance of a new innovation is based on its relative advantage, compatibility with existing cultural values, the degree of difficulty to understand and use, and the ability for the adopter to experiment with the innovation, observe it on their farm, and adapt (Rogers 2003).

This theory also highlights the potential for opinion leaders, such as IFELA recipients, to serve as a model for others to emulate in their social network (Rogers 2003). This theoretical perspective provides a lens through which we can understand how IFELA recipients are positioned within the social system to be a model for conservation behavior for others. For this study, we adopt Rogers' conceptualization of opinion leadership and innovative behavior. Opinion leadership is defined by an individual's ability to influence others in their social network (Rogers 2003). Opinion leaders conform to the social systems' norms, but also use new practices (Rogers 2003). In this respect IFELA recipients have a dual role of balancing the status quo of production expectations with innovative conservation efforts. By examining those who are

[1] Agroecology is defined as the use of ecological concepts and principles in the design and management of environmental systems (Gliessman et al. 1998) for desired outcomes. Outcomes include improving environmental health as well as promoting productive cropping systems (Gliessman et al. 1998).

exemplary stewards of the land, we can gain greater insight into the contextual factors that shape their behavior.

A limitation in the diffusion of innovations approach is that the variables that have been traditionally used as predictors have not explained conservation adoption effectively. The theory focuses on individual as autonomous, rational actors within a system. This approach neglects the ways that individuals are affected by the larger social system. In this view, the success or failure of an innovation rests on individuals' shoulders rather than seeing the adoption or rejection of an innovation as a characterization of how the system functions (Haider and Kreps 2004). In this perspective, contextual factors are often generalized and placed in the background. We would like to expand on the theory of diffusion of innovations to include these contextual factors that may have an impact on conservation adoption and the resulting agroecological health of the land.

CAS informs our framework by examining how diversity and context-specific factors within the economic, social, and ecological systems affect agroecological outcomes. CAS approaches seek to understand complexity by observing how macro-scale structures interact with micro-scale structures across time and space (Meadows 2008). The concept of resilience is central to this theory. Resilience is defined by the coupling of social and ecological systems to withstand disruptions, or new circumstances, and maintain stability through adaptive management (Walker et al. 2004; Folke et al. 2004; Folke et al. 2010; Adger 2000). Systems at different scales absorb new information and adjust through feedback loops across time and space. These work to build holistic stability and enable a socially desired state-of-being (Meadows 2008) that bridges social and ecological systems together. That is, CAS provides a structure through which we can view the reflexive processes between farmer decision-making and the agroecological health of their land.

DOI stresses the importance of agency within decision-making while CAS emphasizes structure in building system resiliency. Both theories conceptualize processes and systems as asymmetric in time; examine the diversity in structure and function of system components, and the emergent change that occurs in response to changes in the environment (Rogers et al. 2005). Combining these theories allows for us to connect the decisions farmers make in conservation adoption to agroecological outcomes.

Agrarianism, Land Stewardship, and Agroecology

Farming in the United States has historically been considered within the moral and political philosophical realms of the agrarian construct (Thompson and Hilde 2000). Agrarianism is a longstanding, broad social philosophy that dates back to Jeffersonian times in the U.S. This philosophy has recently gained popularity because of the negative social, economic, and ecological consequences of high-input production agriculture (Freyfogle 2001). Since this is such a broad term that can be applied in both the urban and rural context, we confine our focus to the contextual factors that shape the family farm as a component of agrarianism due to its significance in conservation behavior. We use Freyfogle's (2001) definition of the agrarian farmstead, which is:

> "The well-run farmstead that provides the locus and cultural center of a family's life, the place where the young are socialized and taught, where stories arise and are passed down, where leisure is enjoyed, where the tasks of daily living are performed, and where various economic enterprises take place, in garden, orchard, kitchen, woodlot, toolshed, and yard" (Freyfogle 2001, p. XIV).

Also in the context of the family, farmers employ a set of guiding principles or ethics that establish accountability in the management of their farm. This includes how they orient themselves to their work. A farmer's guiding principles, or ethics, dictate the level of effort s/he places in the management of his/her operation and the type of rewards s/he seeks to get from farming as an occupation. These guiding ethics can originate from farming background, religion, and/or personal and familial convictions. In this study, a stewardship ethic is defined as:

> "the responsible use (including conservation) of natural resources in a way that takes full and balanced account of the interests of society, future generations, and other species, as well as of private needs, and accepts significant answerability to society" (Worrell and Appleby 1999, p. 269).

In this study, we examine the context of the family farm along with the land stewardship ethic to understand influences that are economic, ecological, and social.

Prior research by Salamon and associates on the spatial and temporal aspects of conservation considers agrarianism to be a foundation of the family farm (Salamon 1985, 1992, 1995; Salamon et al. 1997). Conservation of the soil and its productive capacity is tied to long-term family farm continuity (Salamon 1985). Improving soil health through conservation practices builds a farm that can be productive and can be passed on for many generations. In Salamon's 1992 publication *Prairie Patrimony*, agrarian beliefs are highly emphasized in the day-to-day decision-making and the long-term operation of the family farm. Salamon's (1992) study places weight on the nuclear farm family as the catalyst to the production and inheritance of the agrarian tradition. This is because the family farm is a collision between the private family household and production agriculture (Salamon 1992). As a result, decision-making on the farm is shaped by the farm family's goals (Salamon 1992).

Familial agrarian traditions intervene in the external elements affecting the family farm, which are information sources, the community, and technologies and practices they choose to adopt or reject. This work emphasizes ethnicity in the production of family farm culture that reaches back multiple generations (Salamon 1992). Salamon (1992) states the agrarian-centered or “yeoman” farmer is one who views the land as sacred, and so it is maintained for the purpose of sustaining the agrarian lifestyle and enabling family farm continuity. Research shows the multivariate nature of agrarianism cannot be reduced to a single structural anchor (in this case ethnicity); rather it is credited to a diverse alignment of values (Dalecki and Coughenour 1992). In other words, the concepts within the agrarian tradition are more important than where they originate from (Dalecki and Coughenour 1992).

Salamon’s later work with other researchers evolved to explicitly explore the differences between conventional and sustainable farm families in relation to context rather than strictly cultural influences (Salamon et al. 1997). This means that the differences between conventional and sustainable farm families included family traditions, family resource conservation and spending, and events the families experienced that are associated with environmental consequences of agriculture (Salamon et al. 1997). Researchers found that sustainable families maintain older equipment, are inclined to experiment with their land, and are more frugal with their resources (Salamon et al. 1997). Conventional farmers saw older equipment as a sign of financial stress and viewed altering practices as poor land management (Salamon et al. 1997). Salamon et al. (1997) argued that the actions carried out by both sets of farmers strengthened their beliefs about what farming was to them. For sustainable farmers, farming is more than an occupation, but about the family and building resilience for the future. The findings from their study emphasize the importance of examining conservation adoption as a farm-family activity rather than an individual farmer activity (Salamon et al. 1997).

In summary, the concepts of agrarianism and land stewardship inform our study by outlining that land stewardship is about working towards improving production above the ground as well as protecting the health of the soil below. Stewardship is also about the farmers' ability to have a dialogue with the land through the practices they carry out. The empirical data on conservation-oriented farm families shows they have the tendency to be more innovative, conservative with their resources, and have a penchant for on-farm experimentation, which exemplifies this reflexive process (Salamon et al. 1997). Conservation-oriented farm families work their land with the intention to build a resilient operation in line with an intergenerational commitment to farming that shapes their decision-making.

Conceptual Model

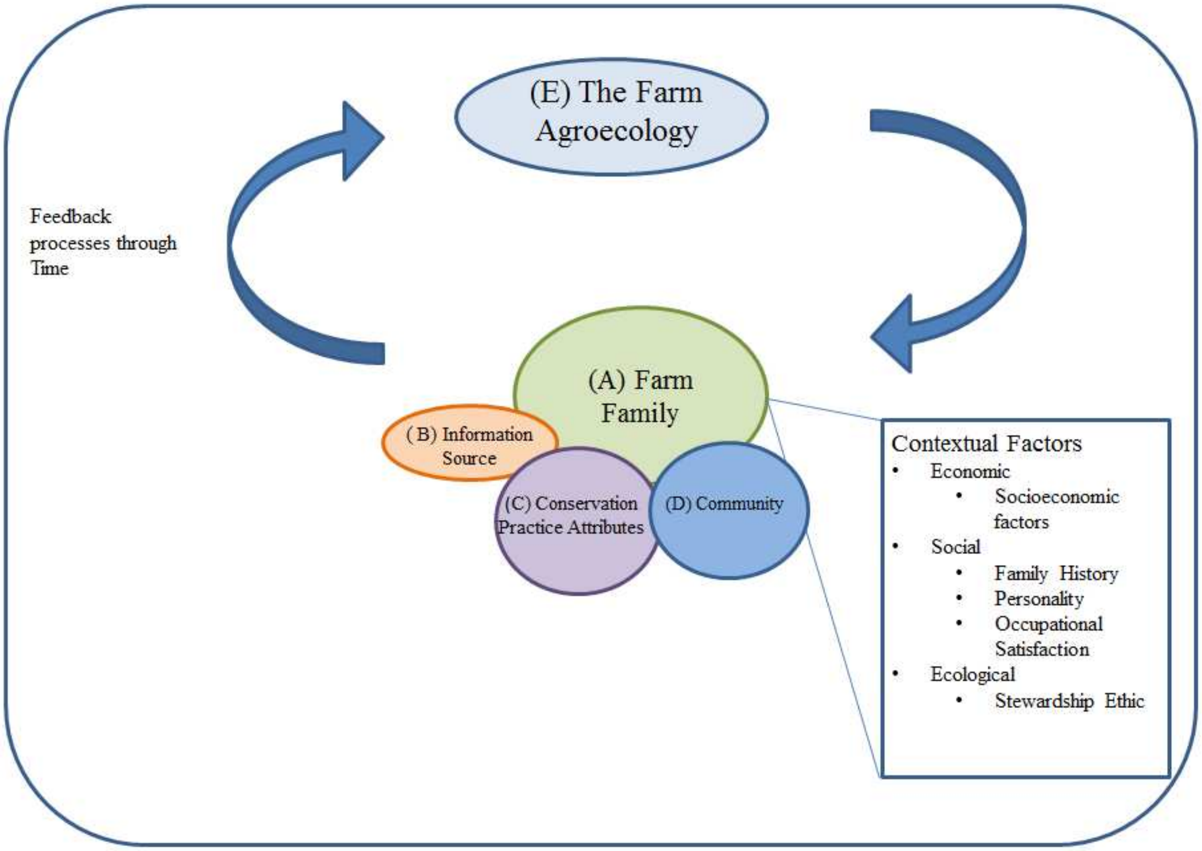

Figure 1. DOI-CAS Conceptual Model.

In this study, we examine the factors that contribute to exemplary conservation behavior of conservation opinion leaders. In our analysis of data collected from farm families, we explore how these factors overlap with farm families' social communities, information sources, and the attributes they see in their chosen conservation practices. The analysis starts with an examination of the of the farm family (A) as the base of the conceptual framework that mediates external elements that affect the family farm, such as information sources (B), and the perceived attributes of chosen conservation practices (C), and the local community (D). The agroecological health of the farm results from the interplay of these factors (E).

For this analysis, the elements of CAS we will examine are the nonlinear directionality of feedback loops, diversity within the population, and the connecting flow of information that makes the system whole (Levin 1998). A key component of this conceptual framework is that these systemic feedback loops are nonlinear and continuous (Levin 1998). The relationships capture both historical trends as well as new possible outcomes that are dynamic in nature (Levin 1998).

Feedback loops operate at different rates of speed. Fast feedback loops include plant growth and economic production systems while slow feedback loops include broad biophysical change and human cultural and political systems (Hollings et al. 2002). To enable resilience, farmers must balance short-term intensive crop production with long-term agroecological health. They must balance short-term economic gains with long-term farm operation continuity. These dynamics within these systems are contextual and reflexive (Hollings 2001). The interactions between social and ecological systems can be both creative and conservative, combining learning with continuity (Hollings 2001).

There are many possible outcomes in our conceptual model depending on the type of social actors that take on the different social roles. For example, if a farmer in the system is interested in conservation and turns to an information source and others in the community to learn about conservation practices, s/he may have a positive impact on resulting agroecological health. Contrary to this, a farmer may have a negative impact on agroecological health due to social and economic factors. Farmers who are motivated by factors, such as a high market value of corn, may turn to production-oriented information sources and use practices that may maximize crop yield, but create negative outcomes for soil health and water quality.

In this paper, we seek to examine how farm families that are exemplary stewards of the land balance economic, social, and ecological factors to build resilient farm operations. The results section later in the paper is organized by contextual themes to address our research question. The factors that shape a family farm will be explored in our analysis of the data. We will use quotes from farmers in this study to illustrate the importance of these contextual factors in mediating the relationships between the family farm and the factors external to the farm.

Methods

Interviews for this study occurred during the summer and fall of 2014. The study population for this research is recipients of the Iowa Farm Environmental Leadership Award program (IFELA) sponsored by the State of Iowa. Established in 2012, the goals of the award program are to recognize farm families leaders dedicated to building healthy soils and improving water quality (IDALS 2014). The evaluation process for the award examined farm families' conservation practices and their leadership on conservation-related activities in their communities (IDALS 2014). A desired outcome of the IFELA is to place conservation-oriented farmers in the position to lead as an example for how others can integrate environmental stewardship within their operations.

The objectives for data collection were to get to know what motivated participants to incorporate conservation practices and to understand the goals they set for their farm. Incorporating new practices into farm management does not come without challenges, and so other objectives included understanding the barriers participants face in conservation practice adoption and how they work to surpass them. A subsequent objective for data collection was to understand participants' attitudes and beliefs regarding environmental stewardship in the context of corn and soybean agriculture. The results presented in this paper are drawn from analyses of interviews conducted with 28 participants from 20 family farms who received the award in 2012 or 2013. Participants' farms were located throughout the State of Iowa.

The unit of analysis for the study is the farm family. We used a purposive sampling strategy to invite farmers to participate in the study. We were interested in interviewing exemplary stewards of the land, even relative to IFELA recipients. This was in effort to locate models of conservation behavior as informed by DOI. Using a search engine, we looked up each recipient's name along with the words "Iowa" and "farmer." IFELA recipients who had at least three search engine hits within the first three browser pages were compiled into a list. Search engine hits included articles from mainstream news outlets, features by farm and natural resource organizations, and sponsored events and/or field days at the IFELA recipient's farm. Mainstream news outlets that featured IFELA recipients ranged from local newspapers to national papers, such as *The Wall Street Journal* and *The New York Times*. Search engine results varied in digital formats that included online-only publications, printed publications, and videos from YouTube. With these farmers being featured by news outlets and farm organizations, it shows that others in the community and beyond view them as experts in agriculture and primary examples of exemplary conservation behavior.

Interviews were held with the farm operations' decision makers (sometimes multiple), and with other family members who participated in the overall management of the farms when possible. As a result, some interviews were held with individual farmers, others with husband-and-wife teams, and intergenerational farmer-successor teams. The farm sizes ranged from approximately 320 to 8,000 acres and all grew corn and soybeans in a variety of different annual crop rotations, sometimes integrated with another cash crop in rotation. Some of these operations included livestock. The farmers used a diverse set of conservation practices that include more commonly used practices, such as soil testing and crop rotations as well as newer approaches, such as variable rate fertilizer application. All farm families in this study came from multigenerational farming operations where the estimated date of family farm establishment ranged from the late-1800s to the mid-1940s.

Weiss (1994) and Rubin and Rubin's (2012) methodology for qualitative interviews informed the development of interview questions, analysis, and collection of the data for this study. Interviews were based on a protocol established prior to the start of the interview process. The questions in the protocol addressed family farm history, the current management practices and goals for the operation, and participants' perspective of being an environmental leader in Iowa. The protocol allowed for follow-up questions and probes to gather rich data on themes, concepts, and events the participant introduced to the interview (Rubin and Rubin 2012). Semi-structured interviews were conducted with the objective to understand personal experiences, perceptions, how specific events affected participants' mindset, and the meanings they derive from various relationships (Weiss 1994).

In the following section, we will describe the contextual factors that provide the foundation for the agrarian farm family and how these factors mediate relationships with the community, information sources, and the use of conservation practices. The outcome of these relationships is farm agroecological health. These descriptions include the accounts and direct quotes from the farmers who participated in the study. The reporting procedure for the results section is based on a numbering system to protect participants' identities.

Results

This section will address how farmers who are already exemplary stewards of the land balance economics, ecology, and social factors in relation to conservation practices that support agroecological health. Our results show that the intergenerational commitment to farming mediates the balance between the need for the farm operation to be profitable and the farmer's desire to preserve agroecological health. The discussions revealed that study participants think in both the short-term and the long-term in managing their operation to balance the current economic status of their farm with longstanding conservation goals through systemic feedback loops.

Farmers were asked several questions about their conservation management decision-making. After we established in the interviews the types of practices farmers successfully integrated into their farms, we were interested in identifying how farmers maintain conservation practices for the long-term. The analysis of the interviews revealed that economic, ecological, and social contextual factors contribute to a commitment to the family farm that enables resiliency. Although they are individual factors in their own right, they do not exist in isolation of each other. The factors in society that often block or enable the path to resiliency are a combination of social, ecological, and economic factors (Hollings et al. 2002). The following descriptions will show how these factors exist as separate and overlapping entities that influence the balance between economics and agroecology.

Balancing short-term economic gains and long-term agroecological goals

The DOI-CAS conceptual model examines the role economics play in the farm operation. CAS theory informs our examination of this factor by conceptualizing the limits of farm economics (scale) and the importance of individual self-restraint in their financial approach to land management. These actions support economic resiliency. For example, when farmers use their financial resources prudently within the operation, it enables resilience. This is opposed using the maximum bank credit available to purchase new machinery or excess inputs (i.e.

overextending their financial resources). When individuals take advantage of economic opportunities, such as maximizing yield to attain the high market values for commodity crops, it may lead to eventual ecological and social collapse (Hollings et al. 2002). Individuals working towards resilience acknowledge that they are dealing with finite resources (both financial and ecological), and so they exercise self-control with what they have. The following descriptions and quotes from the farmers are examples of the economic contextual factor of our conceptual model based on DOI and CAS (Figure 1).

When considering the financial state of their operation, the participants in this study consider a number of concessions in what could benefit the farm now, such as yield maximization or using every inch of their acres to plant row crops. Most participants shared that they do not seek to maximize short-term profits, seeking instead to maintain a comfortable, steady income. A typical economic goal for the farmers in this study was to prioritize the long-term quality of the farm over quantity in short-term farm management. This was a consistent belief for all of the factors that go into farm production from seed plant to crop harvest. This included fertilizer purchases, maintaining older equipment, and valuing their work based off time spent per acre on their farm. That is, research participants expressed that they strive to accomplish more with less. Farmer 1, a self-proclaimed diversified farmer who manages 350 acres on a corn-soybean-alfalfa rotation and a 50-60 head cow-calf operation, highly emphasized land quality in openly stating his goal: “do a good job with what I have first before I’d get more.” His immediate focus in discussing his operation was on economics and how he does not like to invest in depreciable assets, such as equipment. His justification for using older equipment is that it works just the same as new equipment, and so he can use his money towards conservation investments in his farm ground. His operation, like many others in the study, didn’t have the newest, top-of-the-line equipment or well-equipped workshops to maintain equipment year-round. The soil is viewed as a primary asset to the farm and is largely considered to be a priority relative to the assets that can break down or put their farm financially at risk.

For some, assets symbolized the greater trends occurring in agriculture or as a means to "keep up with the Jones." Farmer 16, whose family farm was established in 1854, described his struggle to find small machinery to fit the size of his farm acres:

> "It's difficult. It really is. There aren't – there aren't many neighbors around who are the same size, so there isn't much - there isn't much sharing of equipment, there isn't much sharing of comradery, you know most of it has gotten bigger. It is – it's just is what it is..."

Farmer 16's struggle with finding comradery in agriculture is shaped by the changes he's seen in his community. He stated that in his father's generation, farmers frequently worked together, but as technological advancements occurred in agriculture, it required less cooperation among farmers and a smaller farmer population in general. The prioritization of economic gains is also seen as a threat from urban areas that seek to redevelop land for residential use. Across the fence line from Farmer 16's farmstead construction was underway for a new housing development. A priority for Farmer 16 was to preserve the farmstead against urban sprawl, which means working to be economically viable in his own way in what he perceives to be an asset driven industry.

The popular perception among study participants was that agriculture is getting larger. They see that there is a greater emphasis by the industry on the assets and yield output of the farm as a sign of success rather than the quality return on investments of the farm. Study participants did not identify themselves with this worldview. When most study participants did purchase newer assets, it was a result of absolute need rather than to "keep up" with other farmers in the area. The farmers in this study saw that using their economic resources to invest in the health of the land as more important than buying new equipment. This is also captured in the following statement by Farmer 1:

> "You look at some of my equipment here, I mean, the tractors aren't maybe the fanciest, but they do the same job as a tractor that cost three times as much. I guess I'd rather – and I'm not picking on people who have newer equipment – I'm just saying that I'd rather put my money and resources towards the things that are going to help me conserve the land, you know, like terraces, waterways, filter strips."

Participants often contrasted their approaches with those of farmers that they characterized as typical conventional farmers whose mindset is centered on big acres, equipment, and yields. Contrary to this mindset, the participants placed a greater emphasis on the return on investments to their farm. These were often aspects of their farm that were not readily visible, such as reduced fertilizer inputs. Focus is placed on the net annual revenue of the farm rather than solely on yield output.

Visible investments into participants' farm operations that were are not valued in terms of the "keeping up with the Jones" mindset included riparian buffer strips, cover crops, and waterways that took land out of commodity production. Some study participants often faced criticism in terms of these investments in their farms by those in their farming community. Many study participants discussed the comments made about their farm operations at the local coffee shop as well as roadside conversations they personally had with other farmers. These discussions include "gossip" when the farmer is not around as well frequently unsolicited advice from local farmers and consultants. In response, study participants look inward on themselves, what their goals are, and what they value in their farm operation Farmer 6 stated,

> "I guess it has to be personality, that's the only different I can really see. Some people - I don't go to the coffee shop, I don't go to the bar, the tavern, at night, and that's - some people, that's what they get up in the morning for is to go hear the gossip in town - socialize that way. Where I'd rather take a day and go to a field day and learn something that's going to be of value so my operation so that's - that's the difference there."

Like Farmer 6, most of the study participants differentiate themselves from the typical farmer by stating that they avoid the social situations that reinforce the "Keeping up with the Jones'" mindset. They do not spend a lot of time in local coffee shops or focus on the local competition for yield output. Rather, their focus is on building a quality farm operation with their resources rather than focusing on readily visible aspects of their farm's success according to the status quo in commodity agriculture.

The conversations with study participants consistently identified conservation practices that supported profitability of the farm operation along with supporting agroecological health goals. Some conservation practices, such as tillage, enabled short-term profitability for farmers. Farmer 17, who highly emphasized the importance of economics throughout the conversation, stated, "I'm a businessman and if I can produce a crop with making less trips over the field that makes me more profitable." When Farmer 17 made this statement his wife (Farmer 18) immediately interjected by stating that he is also a conservationist. Their family farm operation incorporated a diverse range of practices that are both cost effective to the farm and improve agroecological health, such as grid sampling and strip tillage that uses precision technology. Farmer 17's wife went on to say that being both business people and conservationists is what makes them different from other farmers.

A nutrient management strategy, which is a plan that reduces the amount of fertilizer applied to farm acres, is identified by study participants as a crucial approach to maintain the balance between economics and ecology. When Farmer 20 was asked to describe the nutrient management strategy he had in place for his farm, he didn't call it a nutrient management strategy. Rather, he understood the strategy to be a tool to save money. He stated, "I just call it practical economics – survival economics." Farmer 20 cited the importance of not spending more money than what the crop is worth in a given year. He states that there are "volume farmers" who go after economies of scale in their operation who fertilize for high yields. To him, this is an expensive approach because high yields are difficult to get out of the land when you're reaching its fertility limits. Farmer 20 distinguished himself from other farmers by stating that he does try to make as much money as he can per acre, *but* he also states that he does it in a way that is responsible and practical.

Based on the conversations with the participants in this study, the other conservation practices that enable cost savings within their operations included soil testing and sampling and using tillage practices that minimally turns the soil on their fields. For Farmer 20, whose farm had always grown row crops, this incorporating cost savings into the operation through conservation practices is primary benefit to his family farm operation that he thought the average farmer out in the Midwest doesn't recognize. He stated,

> "There's a lot of farmers think that they can hit 250 bushel corn, and if the year is right, if all the conditions of weather is right, it's possible. If you fertilize for that every year, not only is it expensive, but you're over applying and the plant can't use as much. Even – it's there, but you have to have an economic return, and I try to get – I don't want to spend a

dollar and get 90 cents back. I want to spend a dollar and get a dollar-five back or dollar-ten back, dollar-twenty back. There's a bell shaped curve on everything."

These practices can provide a cost savings to the farmer relative to nutrient and tillage practices that require more pounds per acre of fertilizer and intensively turn up the soil. They are saving money on fertilizer inputs and spending less time and labor out in the field because they are taking fewer trips across the field.

For Farmer 2, the rationale for how he manages his land is influenced by historical events and market impacts in agriculture. He specifically referenced the Dust Bowl as a time when land was heavily tilled for production, which eventually led to ecological and social collapse within the U.S. He stated the same thing may happen again in the Midwest because there is a focus on production rather than agroecological health of the land. Like many of the participants in the study, Farmer 2 differentiates himself from the average farmer by describing how he doesn't manage his farm to take advantage of the corn and soybean market to maximize profits.

Study participants highly emphasized that the volatility of the commodity market is a motivation for using cost saving conservation practices. At the time of the interviews, the price per bushel of corn was hovering around $3.60 (NASDAQ 2015). Several study participants emphasized the financial implications this price has for farmers in the Midwest. This is because they will receive less of a financial return on their yield output. Although that is the case, the study participants felt generally comfortable with the state of their operation because they have the conservation practices in place that saves money on the inputs to production, such as fuel for tillage and the amount of fertilizer needed to grow corn and soybeans. Having these precautionary measures in place protects them against the booms and busts of the commodity market. This is exemplified in the following dialogue between two farmers who manage one of the family farms in this study:

> Farmer 17: So many people are just looking at the bottom line. What can I do – for the biggest return on investment? You know, throw tons of fertilizer out there, not use precision and just you know throw money at the problem, I'll say. It's all about profitability. What would you say?
>
> Farmer 18: Yeah, I would agree. They haven't really stepped back and taken a look at you know what are we doing to our ground for the future as well as now? Are we saying the soil is important or are we just doing what we need to do to make a profit? Mindset.

Farmers identified judiciously applying fertilizers and overall conservation management as a way to be realistic about what their land can produce and what the needs of their operation is in terms of profitability.

Participants' short-term goals were not to maximize profitability from their land, but to set appropriate goals that stay within the agroecological limits of their farm. This means the participants consider soil health, the cost of inputs, and available labor and equipment when determining what they can sensibly manage within their operation for each growing season. Farmer 17 stated, "We do have yield goals – and we use realistic yield goals. You could use very high ones that are not achievable and then you would be putting fertilizer out there that will not be utilized." All of these considerations are measured against the ecological and social contextual factors that shape the family farm that economics contributes to. Farmer 13, a primary operator on a farm established over 100 years ago, best exemplified this in the following statement:

> "I think we're doing a better job than most folks. I think we're doing a better job on nutrient management, I think we're doing a better job in soil management. Now other people may say, 'yeah, you're not doing good making *money*.' They may be right, but it

> comes back to here (refers to the mission statement of the farm). [That's] what's important to us."

In his family operation, which includes two sons, the focus is on family. Very little help is hired from outside the farm. The operation works to do as much on its own as possible due to the risks the farm faced during the 80s farm crisis. Farmer 13 claimed to have overextended the operation during this time by building a hog house. He also faced a total crop failure during that same time. The bank the farmer borrowed money from attempted to foreclose on the farm, but he was able to manage the debt and keep the farm in the family. As a result of this experience, his family operates the farm with the goal to be efficient and disciplined in how they use their financial resources to enable resiliency. This is because Farmer 13 did not want to lose what previous generations in his family had worked so hard to preserve.

The above examples represent real goals that would likely be seen in any farm operation in Midwest. Maintaining profitability through the upkeep of machinery, selecting the best seeds and chemical inputs, and immediate soil health is on the mind of all farmers because they have to constantly adapt to the market and the weather. Within our conceptual model, the commodity market is a fast process that operates within the short-term. The participants in this study set themselves apart from what they view as the "typical" farmer in Iowa because they not only consider economics, but ecological and social factors within their farm operation. As noted by the DOI-CAS theoretical framework, these two contextual factors operate within slower, long-term systems. The participants in this study recognize this, and so they strike a compromise between how they operate within economic short-term systems and implement practices to support long-term agroecological health. This is in effort to support family farm resilience.

Participants have the ability to see the different possibilities for the land outside of maximizing profits that ebb and flow with the market, which ultimately affects how they financially manage their land. When asked about the financial challenges associated with implementing conservation practices among the general farmer population, Farmer 1 responded:

> “I think back to your mindset. If [you have the] mindset and desire and ambition to do it, you’ll find ways to get it done no matter what they economics are - within reason. But people who just – that’s not their cup of tea - it doesn’t matter how good things are, they - you know, they’re just not going to pursue it.”

How participants manage the economics of their farm operation overlaps with the intentions they have for keeping the land in good, productive condition (ecology) and the values they place in their land (social). The participants’ intergenerational commitment to farming is evident within how they manage the finances of their farm. They operate their farms within the limitations of their resources instead of maximizing on what they can for the short-term. A primary focus is on a better return on investment rather than a focus on outputs, thus exercising discipline in how they manage their resources. Rather than focus on economics as a primary factor, the participants in the study set themselves apart from what they view as the “typical” farmer by demonstrating they balance finances with other management goals that include agroecological outcomes. This is particularly important as economic and social resilience have the ability to be generated in the short-term, but often at the cost of ecological resilience (Berkes and Folke 2002).

Managing the Stocks and Flows of Agroecology

DOI-CAS theoretical framework outlines a holistic system in which different systems operate on different scales and at different speeds. Faster processes include intensive cropping systems and crop market transactions, while slow processes include larger biophysical changes and social developmental change (Hollings et al. 2002). Farmers exist in a complex set of stocks and flows in terms of ecology and economy. Often, individuals tend to focus on expanding the resources they have available (stocks) than reducing what leaves their possession (flows), which disrupts feedback processes and throws the system out of balance (Meadows 2008). For example, a farmer may attempt to maximize his yields by spending money on inputs and fertilizing for extraordinarily high yields at the cost of nutrients leaving the farm and polluting other agroecosystems. Farmers have the capability to be vigilant of these stocks and flows and take action to keep them within stable ranges to support overall resilience (Meadows 2008). Magdoff et al. (1997) argued that "because humans have such a large impact on the globe, the social or human component of agriculture is very important to the subject of nutrient cycling" (p. 4). Recognizing the potential disconnect between the processes of corn and soybean cropping systems and long-term agroecological health is crucial to developing long-term system resilience.

Participants in the study tended to emphasize that the ecological integrity of the land is one of the foundations of a resilient family farm. Most participants saw innate value in the land as a provider of ecosystem services outside of crop production. Ecology is also an important factor in building a resilient family farm for the future. This is enabled through the use of conservation practices. For example, study participants noted that the detrimental aspects of intensive agriculture production affect the soil in a much faster way relative to how fast conservation practices build the soil back up. Soil health to study participants meant building organic matter to keep the soil in place as well as retain nutrients for crop productivity. Farmer 20 stated, "The better you treat your land, the better it'll treat you." To him, this strategy involves constantly fine-tuning conservation management decisions that will eventually have a ripple effect into future productivity and agroecological health of the farm. Farmer 20 stated that he does not use "luxury" amounts of fertilizer. Instead, he fertilizes for realistic goals. He sees working *with* the land as a way to mitigate the pressures of farming. To him, these pressures include carrying on the family tradition and providing for the next generation by keeping the land in good form.

Many study participants tied soil health and conservation to passing on a resilient farm to future generations, and so it is a long-term goal. Farmer 3, a second generation farmer in his late 20s who raises corn and soybeans with his family, stated, "Long term, we want to keep our soil productive so that our kids and our grandkids that will hopefully be farming on these same acres can have ground [that] is just as productive or more productive than the ground – than it is now. That's the hope." Although many study participants felt this was an important goal, they acknowledged the importance of patience because building optimal soil health will take a long time to achieve. Farmer 6, a third generation farmer who manages 1500 acres, continually works to improve his farm ground. To him, land health is a long-term goal that if achieved, will give him a sense of accomplishment with his land management. He stated,

> "I guess you know when the prairies were cleared off and we started farming we had upwards of about – of top soil and we have hilltops like that have virtually none but a couple of inches, and so if we could use no till and strip till and build that layer of topsoil back up. That's going to take you know years, but if we methodically work at it, eventually, you'll make those soils more productive and look back on your life and say 'well, it's better now than when it was when I started.'"

For the farmers in this study, economics and agroecological health had to be mutually beneficial. This is because over the long term farmers must balance profitability with agroecological health. For this to occur, the agroecological system and the social system are considered to be coupled together and have feedback processes that occur through time (Figure 1). This is emphasized by study participants because they are monitoring the ecological integrity of their farms and exercising patience in implementing conservation practices so that their farm may still be resilient for future generations while still producing crops for short-term profit gains.

Intergenerational Commitment to Stewardship

According to DOI, an opinion leader amplifies the efforts from actors outside the system who are trying to change it (Rogers 2003). IFELA recipients are recognized by the State of Iowa as examples for how farmers should go about implementing conservation practices. Leading by example is a social process that not only communicates action, but different social values and identities that are embodied by conservation leaders (Coughenour 2003). IFELA recipients may not be just promoting conservation values, but a different social construct of agriculture.

Farming is often viewed not just an occupation, but a lifestyle choice. A sociological understanding of how a family farm functions cannot be done without examining how members find their place within the farm and the meanings they attach it (Djurfeldt 1996). In this study, all participants came from multigenerational farm families with many intending to pass on their farm to their children and grandchildren. The land succession process that carries on a family legacy engenders a sense of commitment to a stewardship ethic on an intimate level with the farmers within these families. Family legacy as an obligation incites the drive for farmers to have a full and balanced understanding of natural resource conservation that examines economic and ecological consequences of land management for farm continuity.

A majority of study participants viewed farming as more than an occupation to derive an income, and saw ecological and social value in their farm land. The absolute long-term goal identified by a majority of participants was the desire to pass their farm to their children and grandchildren. The social component (Figure 1) of the family farm weighs heavily on the decision-making of farmers in this study because they were socialized from a young age to embrace farming not just as an occupation for income, but as a way of life. Many of the participants in the study made the connection between their relationships with old generations in the family and the value they ascribe to their land. This is in particular in reference to fathers and grandfathers of the study participants. This, in turn, shapes their stewardship ethic and how they treat their farm acres. When Farmer 2 was asked about why he chose farming as an occupation, he immediately responded with laughter that it wasn't a choice. After attending a few semesters in college he felt compelled to rejoin the farm because from his perspective, it was an opportunity that many "kids" his age didn't have access to. Farmer 2 stated:

> "I always loved the land. It's hard to explain. The feeling of land - that you have towards it – the connection – I don't know the word I'm looking for, but when you think about your father and grandfather and great grandfather walked all over this ground, you know, and then to pass it on to your children. It's kind of neat."

Study participants commonly referenced farming as being "in the blood" or as having an "instinct for farming" that started in the core of farm family life and the values they inherit that span multiple generations. Farmer 23, a fourth generation farmer, captured the essence of what farming means to those in the study in the following statement, "My son has this passion, too. Hours mean nothing. Days mean nothing. Getting the job done means something."

Study participants transferred their intersectional valuation of the land into the conservation practices they implemented on their farm fields. The social aspects of the farm family motivated them to manage their land with the goal to pass it on to future generations in good quality. As a result, they are hyperaware of the role conservation plays in enabling farm continuity. Farmer 25, a semi-retired farmer, exemplified this in his relationship with his son who is in the process of inheriting the farm. Their succession plan involves transferring the management of the land on a cash rent basis, and so his son has complete control over the land through an agreement. This is so that there would be no disputes over how the land would be managed. Although Farmer 25's son essentially has free reign in decision-making, one condition in their cash rent agreement was to maintain land stewardship as a core element in the farm management. Farmer 25 stated:

> "… The main thing is our – our deal is – he stay involved with the conservation efforts. That's sort of the only limitation on our agreement. Actually, he's done really good I think on it. Being – staying involved with the conservation ethic."

Overall, participants' relationships with their father, grandfather, and their children have significant ties to conservation management decisions on the farm. Farmer 10, also a semi-retired farmer, was also in the succession planning process with his grandson-in-law. He saw the incorporation of a new generation into the farm as an opportunity to establish a stewardship ethic that had not been strictly held by him in the past. Farmer 10 stated:

> "When we had that $7 corn, $6-7 corn, I got a little greedy. We worked – we were running typically 135 lbs. of nitrogen for soybeans. Going to corn, we were like 150 units going from corn to corn. When this came along, suddenly everything was up to 180 units just because you didn't want to miss that option of lots of corn and lots of money. Now, at this time, now where [he]'s coming in, I felt we needed to start all over again… So now we're kind of starting over again. I felt it was – we need to start with [him] doing the same thing – trying to put where he feels we need to be with those levels. I think we're

probably over providing right now, and that's okay, but we're going to work our way down probably."

Like Farmer 10, many study participants held themselves to a very high standard on conservation. As a result, they were often dissatisfied with the current state of conservation on their farm. Meeting conservation goals was described to be a work-in-progress. In this respect, study participants evaluate the state of their operation on a regular basis. They assess the farm operation in terms of economics and agroecological health, and then make adjustments. Many study participants had a formal mission statement for their farm that captured the goals they hoped to achieve and the importance of family to the operation. Several stated they ran their operation with the overall goal of building resiliency for a future for their families. For Farmer 13, the core values to his family farm were: integrity, family, faith, and land stewardship. The goal for their farm is to be:

> "An enjoyable, profitable, family farm that builds on our heritage and creates a lasting family legacy… [To] be an efficient model grain producer that maximize profit while improving the health and quality of soil, one that others look to for innovations and ideas."

The decision-making in Farmer 13's operation is in interest of family wellbeing and resilience for the future. To him, this requires building an operation that continues to thrive (economic), saves the soil and protects water (ecological), and that the family members within the operation respect each other and their ideas (social). Farmer 13 elaborated on this perspective by stating:

> "The focus of this operation is an operation that goes forward for a long time that the family feels good about, that keeps the soil where it is, that keeps the nutrients where they are, that takes care of the water, it's – everything goes back to the focus of the operation.

Not enough people do this exercise. If you do this exercise honestly, you might decide that you didn't like what you was doing."

Study participants' focus on the social aspects of farming as a way of life rather than solely as a business had a significant impact in how they ran their farm. Leaders not only have the ability to promote conservation practices, but a new way of thinking about agriculture (Coughenour 2003). With the IFELA recipients set up to be role models for other farmers in the State of Iowa, the identity they have and their orientations to the land as being "in the blood" may transfer to others to enable resiliency.

Overall, study participants strike a balance between short-term economic systems and long-term ecological and social systems. Like the conservation-oriented farmers in the study by Coughenour (2003), the study participants continually examined social, economic, and ecological factors that went into their farm. Because of this, they can make decisions now that line up with longstanding conservation goals. In further examination of the data, participants' desired conservation outcomes operate at different speeds across time and space. The concepts of conservation and farm resilience also had different meanings to the participants depending on what place and time they were focused on. When participants were thinking of the present, they thought of conservation in terms of profitability and building a better return on investments. When thinking of conservation in the long-term, they primarily thought of their children, land succession, and more abstract considerations of agroecological health. The study participants make adjustments to their operation with an eye to the future while holding the values and ethics passed down through the family farm constant.

Future Directions

In this study, we examined the relationship between the farm as an agrarian-centered family operation and agroecological health. To meet the goals established in the Iowa Nutrient Reduction Strategy to mitigate fertilizer run-off and soil loss (i.e. build resilience), we found that attention should be focused on the contextual factors that shape conservation-oriented behavior rather than basic farm characteristics and farmer demographics (Lockeretz 1990, Reimer at al. 2014; Prokopy et al. 2008). This is on point when considering long-term solutions, such as the permanent incorporation of innovative conservation practices. As Salamon et al. (1997) states:

> "In addition to ecological sustainability met by farming in environmentally sensitive ways, concern must be focused on social sustainability that preserves decisions made by one generation when the next generation takes over" (Salamon et al. 1997, p. 271).

For a family farm operation to be resilient for intergenerational transfer, it must balance short-term profitability with the long-term health of the landscape for future productivity. Our research shows that the intergenerational commitment to farming may serve as a key element that has a large impact on conservation decision-making. The farm families in this study largely exist as a closed system that carefully measure external factors, such as technological and informational inputs, against the beliefs about farming they cultivate within the family. This is with the goal of preserving the farm for the future rather than just focusing on the present. The resulting agroecological health of the farm is ultimately a consequence of how family intervenes with these factors external to the operation. Overall, farm families in this study regularly measure the state of their operation against what is reinforced by the family, make adjustments, and constantly work to maintain resiliency.

Farmers maintain multiple identities as food, fuel, and fiber producers and stewards of the land (McGuire et al. 2012). Based on our results, the commitment to intergenerational land transfer may serve as a crucial aspect that has a significant effect on conservation decision-making that balances being a producer and being an environmental steward. This commitment is shaped by economic, ecological, and social contextual factors that are reflexive in nature and are shaped through time and across different spaces farmers navigate. Our findings are consistent with previous studies in conservation adoption that emphasize the importance of the farm family in working towards resilient agriculture (Salamon et al. 1997).

A shortcoming to this approach in understanding conservation adoption is that not all farms in Iowa are family farms that have a long family history as those in this study. Rather, they may be in the first or second generation of ownership or may not have any interested children or other successors at all to pass the operation on to. According to the 2009 IFRLP, 42 percent of farmers planned to retired within the following five years of the poll while only 56 percent had identified a successor for their farm land. Future research could examine the contextual factors that shape farm operations that are absent of a commitment to intergenerational land transfer and how they work towards building resiliency.

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CHAPTER 4: SUMMARY AND CONCLUSIONS

The growing evidence of Midwestern agriculture's contribution to soil erosion and water impairments in the Gulf of Mexico demonstrates the need to understand farmer behavior in relation to agroecological outcomes. Farmers are not only faced with the pressure to meet yield demands in corn and soybeans for the market, but also to remain profitable within their farm operations from year-to-year. A consequence of yield prioritization is the externalization of the environmental impacts of agriculture to other ecosystems and to society. With the growing recognition of these impacts, farmers are now openly tasked with the responsibility to manage their land in an environmentally responsible way (ISU 2012).

The State of Iowa has publicly acknowledged its role in water quality impairments by developing its own nutrient reduction strategy (ISU 2012). The strategy offers what it posits as a practical, coordinated approach using existing and new practices and technology for nutrient pollution mitigation. Action items for agriculture can be organized into five categories. These are: setting priorities; documenting progress; research and technology; strengthening outreach, education, and collaboration; and funding (ISU 2012).

Even with this comprehensive approach, progress towards the goals outlined in the Iowa Nutrient Reduction Strategy since its release has been slow. Some of the action items outlined in the Iowa NRS are receiving a greater emphasis than others, which neglects key areas that could effectively assist farmers in reaching water quality goals. For example, financial incentives for conservation programming has a heavy emphasis within the current approach. Areas that have not received as much attention include outreach and education efforts through participatory processes (Nowak 2009). Some commissioners from the Soil and Water Conservation Districts in Iowa have even publicly called upon the State of Iowa to restore funding to support water quality initiatives within soil and water conservation districts (Taha et al. 2015).

Researchers and state agencies have recognized that there is no single conservation practice that can achieve overall water quality goals established by the Nutrient Reduction Strategy (ISU 2012, McLellan et al. 2015; Castellano and Helmers 2015). It is also acknowledged that no farm field is the same, and so the outcomes from the use of nutrient management practices on one farm may not be the same as on another (Haycock and Muscott 1995). Research is needed to examine the diversity in nutrient management practice use in conjunction with engagement and collaboration among stakeholders in the agriculture community. As the findings in this thesis show, the relationship between farmers and their social network may be crucial to the implementation of diverse nutrient management practices to achieve water quality goals.

Diffusion of innovations theory and complex adaptive systems theory provide valuable insight into understanding the interconnection within and across social and natural systems that influence farmer decision-making. As noted earlier in the thesis, the diffusion of innovations theory is rooted within the social sciences; wherein innovations and new ideas diffuse through networks of people through time (Rogers 2003). Complex adaptive systems theory originates from the natural sciences and emphasizes structure and feedback processes within systems (Levin 1998). Rogers et al. (2005) demonstrate that these theories are complementary because they examine how changes occur in time, place an emphasis on diversity within the social system, and explore how individuals respond to the challenges and opportunities they are presented with in ecology, society, and economy.

Throughout each paper in this thesis, there is a strong presence of a relationship between the individual behavior in land management and resulting agroecology. The role of social networks examined through the lens of diffusion of innovations theory and complex adaptive systems theory aided in understanding the factors associated with diverse nutrient management practice use. Our findings from Chapter 2 show the use of information sources had a significant and positive relationship with the diversity in nutrient management practice use. Opinion leadership also had a significant and positive relationship with diverse nutrient management practice use. Overall, these findings indicated the importance of social networks in enabling the adoption process of a diverse set of nutrient management practices.

As described in Chapter 3, there was wide recognition among study participants that the actions they took on their farm had resounding effects beyond their farm fields, on both society and on other ecosystems. Different factors within a farmer's world - economic, ecological, and social - are interdependent. As seen in the DOI-CAS framework (Figure 1, Chapter 3), how these factors interact may create the context for a farm operation to either be resilient or head down a path towards social-ecological collapse. The interaction between society and agroecology is not a one-way street where a social interaction leads to an agroecological outcome, but an iterative process where agroecology, in turn, affects farmer decision-making. Farmers working towards resilience within their operation have the ability to tolerate change as well as maintain stability through adaptive responses. Our findings show that Iowa family farms that are perceived as environmental leaders actively work towards resilience within their operations. They do so by balancing short-term economic gains with long-term agroecological outcomes. They are motivated to do so to honor prior family legacy as well as to pass on their farm in good, productive condition to future generations.

Limitations and Future Directions

Each paper in this thesis serves as just the beginning of the exploration of two research questions, neither of which has received adequate attention by the scientific community in recent years. Based on our findings, research in the social and contextual factors that shape conservation decision-making should be continued. Not only this, but future research should pay closer attention to the role that opinion leaders may play in the adoption and diffusion of diverse conservation practice adoption. In this section, I will discuss the limitations faced in this study as well as future directions for research.

Understanding Information Sources

In our study of the social factors that are associated with diversity in nutrient management practice use, it was our intent to establish a baseline relationship between social network factors and diverse nutrient management practice use. This is because prior research showed positive relationships between social network factors and the adoption of a single practice or a collection of similar practices (Prokopy et al. 2008). Future research should explore how social ties are formed and maintained between farmers and information sources, particularly in respect to diverse nutrient management practice use.

As we analyzed the variables related to information sources, deeper theoretical concepts from the diffusion of innovations theory became apparent as potential ways to guide research to improve the understanding of the effect these variables have on diverse nutrient management practice use. The diffusion of innovation theory states that the links between individuals in a system can have various measures of homophily (similarities) or heterophily (diversity) with an information source (Rogers 2003). Homophily "refers to the extent of prior affinity among network actors, including proneness to accept innovation[s]" (Rogers et al. 2005, p. 11).

Homophilous relationships require less energy to transfer information from person-to-person because they are culturally similar (Rogers et al. 2005). Heterophily is the extent to which individuals who interact with each other are dissimilar (Rogers 2003). Rogers et al. (2005) state that the higher amount of heterophily, the more energy that is required to promote the innovation. The dissimilarity in expertise, socioeconomic status, beliefs, and language may lead to misinterpretations, and so information can be overlooked by the receiver (Rogers 2003).

For individuals within a system to adopt a new innovation there must be some amount of diversity, but not too much (Prell et al. 2010). Different information sources present within farmers' social networks may represent different proportions of homophily or heterophily with farmers. For example, a private sector seed dealer may be more culturally like a farmer. This may be because the dealer is a part of farmers' communities, and so they have a deeper understanding of the interests they have and challenges they face (Ingram 2008). They may be able to communicate more easily, but the information exchange between the two actors may not necessarily introduce new, innovative information to the farmer (Rogers 2003). In contrast, a source that is unlike a farmer may include a university agronomist. This individual may not be culturally similar to a farmer because their primary work is in agriculture research and development. The information exchange between the farmer and this type of information source may introduce new information, but since the two social actors may be dissimilar, the exchange may not be very efficient in the adoption and diffusion of information. Other possibilities include social actors, such as opinion leaders, who embody both homophily and heterophily with others in their social system (Rogers 2003).

Since our findings suggest that there are positive relationships between farmers and a variety of information sources on diverse nutrient management practice use, future research could examine the qualitative differences between these information sources to examine similarity and diversity among social actors. Applying this theoretical approach could help guide research to lead to an improved understanding of what kinds of relationships farmers are more receptive to - ones that are more culturally alike or ones that are more culturally dissimilar.

Examining Opinion Leaders

A significant finding in Chapter 2 is the relationship between opinion leaders and the diversity in nutrient management practice use. The diffusion of innovations theory emphasizes the role that opinion leaders play in the adoption and diffusion of innovations (Rogers 2003). Our findings support prior research that examines the importance of leadership in relation to conservation practice use (Coughenour 2003, Pannell et al. 2006; McGuire et al. 2012). Rogers (2003) argued that opinion leaders have the ability to amplify the efforts of those from outside the system who are trying to change the system. Opinion leaders have the ability to serve as role models to others because they balance following social system rules and norms with incorporating new ideas and innovations in their lives (Rogers 2003). Future research should seek to understand how opinion leadership is defined and operationalized within local farming communities.

Exploring Farm Resilience

Our findings in chapter 3 showed the different ways in which farmers balance economics with environmental stewardship to build a resilient operation. To these family farms, resilience meant passing their farm on in good, productive condition to the next generation. In their perspective, the incorporation of conservation practices into their operations enables them to do so. They made a commitment to intergenerational land transfer that motivates them to balance the economic, ecological, and social needs within the farm.

In this research, we focused of farmers who were recognized by the State of Iowa as being conservation leaders. This allowed us to begin to understand how those who are oriented as role models in the system go about balancing short-term profitability with long-term agroecological outcomes. Farmers are a heterogeneous group in society who have many identities (McGuire et al. 2012), and so a focus on one type of farmer should not characterize all farmers. Our study did not include conventional farmers. As a consequence, we were not able to draw comparisons between conservation-oriented and conventional farmers to explicitly state how these two groups are different. Salamon et al. (1997) conducted research that compared sustainable farmers and conventional farmers and found significant differences between the two groups. We were restricted in the size and scope of this research due to funding limitations. Future research should consider addressing this shortcoming by conducting a comparative study to build on our findings.

Another shortcoming to this approach in understanding conservation adoption is that of all the farmers Iowa, not all of them are intergenerational farms with a long family legacy. A family farm operation may not have children within the operation who are interested in work on the farm, or the operation may not have any potential successors at all. Future research could look into the contextual factors that shape farms that lack a familial commitment to intergenerational land transfer. This is to examine how current landowners work towards building a resilient farming operation for the future.

Conclusion

In closing, I would like to return to the topic of the resiliency and the role that systems thinking plays in understanding how the agriculture industry functions in the Midwest. We live in a complex set of systems where the economy is contained by society, which is ultimately bounded by the environment (Daly and Farley 2010). Our social interests are revealed through what we value within the market (Daly and Farley 2010). In the current state of the agriculture system, there is misplaced concreteness, wherein economics is prioritized over social and ecological welfare. The pressure for crop productivity has lessened the focus on ecosystem services, such as clean water in farm management strategies (Robertson and Swinton 2005). Because of this, the agriculture industry as a whole has become complicit in a leaky agricultural system that leads to negative externalities, such fertilizer run-off, onto society. The evidence of society's priorities is seen in the water impairments within Iowa and in the Gulf of Mexico hypoxic zone (Diaz and Rosenberg 2008, Boesch et al. 2009; EPA 2012, Rabotyagov et al. 2014). This orientation separates the environment from society and the economy, thus decoupling entities that must work together to build resilience for the future.

Current programs and policies to address nutrient loss also prioritize the economy by emphasizing cost supports for conservation practices. The dialogue on conservation is financial rather than on modifying how farmers and society thinks about the soil. This dialogue is what Nowak (2009) contrasts as doing things right versus doing the right thing. Acknowledging economic, ecological, and social factors together, rather than prioritizing one over the other enables resiliency (Hollings 2001). Examining water quality impairments through the lens of diffusion of innovations and complex adaptive systems theory brings the social and ecological worlds together and acknowledges the human dimensions of natural resource management. Research that emphasizes participatory processes and contextual factors that shape farm operations may have the potential to aid in creating better outcomes for agroecological health both in Iowa and downstream.

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