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Temporal reference and intergenerational timescales of agricultural conservation under variable climate

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ABSTRACT

Agriculture is a complex human-natural system with intricate and continuous feedback loops that bring the past forward into the present and the future. Like all humans, farmers learn from the past. Intergenerational narratives and experiences with recent past extreme weather events and variable climate patterns frequently become analog years used as benchmarks to build knowledge of the natural environment and guide decisions. However, there is a lack of knowledge about how individuals plan and structure the timescales between decision, action, and outcome. For example, why do some people seem to act on “shorter” timescales without regard for long-term consequences of their actions to themselves, others, or the environment? And why do others make decisions based on “longer” timescales in order to preserve resources for the sake of future use? Although agricultural and climate sciences are continuously advancing our understanding of crop management, fewer investments have been made to understand the crucial human element. There is a need to better understand the timescales of social and cultural factors which influence reception (or rejection) of advances in scientific knowledge. How do time perspectives—the orientation to time and pathways of time—influence interpretation of information and decisions made to implement conservation practices on agricultural lands? What are the disjunctures between how humans perceive and reference long-term timescales of changing climatic conditions and short-term timescales of annual crop production?

This dissertation seeks to expand understanding of farmer decision-making as it relates to timescales, climate change, corn-based cropping systems, and advances in science for agricultural decision support. First a temporal reference framework is developed to explain the processes by which past experiences and intergenerational narratives are brought forward in time to inform current agricultural management decisions. Then, this theory is elaborated and empirically tested in Chapters 4 and 5. A purposeful sample of interviews with corn farmers (N=159) and climatologists (N=22) in nine upper Midwest states (Wisconsin, Indiana, Iowa, Minnesota, Michigan, Ohio, Illinois, South Dakota, and Illinois) and a random sample farmer survey (N=1,159) from the 2015 Iowa Farm and Rural Life Poll provide data for these analyses. Chapter 4 conducts binary logistic regression on the survey of Iowa farmers to evaluate the influence of previous generations and social pressures on decisions to decrease fall tillage, increase no tillage, and increase the use of cover crops on their farm. Family-level norms and pressures are shown to reinforce traditional crop production practices such as the action of post-

harvest soil tillage. Chapter 5 explores the weight that farmers and climatologists give to historical experiences in interpreting climate conditions and their effects on production systems by analyzing in-person farmer interview data. Inductive reasoning is utilized to detect common themes involving temporal orientations and temporal pathways that influence agricultural decision-making.

Findings suggest that farmers are influenced by historical intergenerational narratives of family farm management practices. Higher weights are often placed upon personally experienced past events and narratives of analogous historical conditions than predictions or expectations of future environmental conditions. Farmers are more likely to consider decisions relative to a past time orientation which reinforces pathways of time as socially-referenced to cyclical intergenerational events. This may result in farmers perceiving environmental conditions as maintaining stability through reoccurrence of environmental weather and climate risks. This suggests that scientific information describing early warning signals of future climate disruptions and opportunities for agricultural management adaption may not be resonating with the farming population.

This research offers a contribution to further understand the role of timescales—temporal perspectives, orientations, and pathways—associated with decisions about agricultural production and climate. Implications of these findings may be helpful for scientists, educators, and other agricultural stakeholders who seek to connect advances in climate science with opportunities for agricultural adaptation. Recommendations involve building the capacity of information facilitators, or individuals skilled in communicating and framing science in messaging which resonates to intergenerational narratives of farm and soil conservation. Scientists should find ways to involve farmers in the co-production of knowledge to increase understanding of timescale perspectives in the interpretation of scientific knowledge. As agriculture adapts to changing climate and environmental conditions, decision-makers may need to continually assess and reconsider the trajectory of predominant corn-based cropping management.

CHAPTER 1.

GENERAL INTRODUCTION

Unless we change the direction we are heading, we might end up where we are going.

- *Chinese Proverb*

Introduction

Perception of time remains an understudied factor of individual and collective decision-making (Luscher 1974; Bergmann 1992; Zeitlyn 2015). Despite evidence that temporal orientation is a significant predictor variable for support of climate change policy (Dietz et al. 2007), the temporal component of natural resource conservation adoption continues to receive little attention from researchers (Reimer et al. 2014). Many agricultural conservation practices, such as reduced tillage and cover cropping, produce agronomic and environmental benefits that are compounding over time (Lal, 1993, 2004; Grandy et al., 2006). In other words, benefits of these management practices may not be realized within annual time cycles; rather, benefits accrue in longer-term time horizons. As a result, it may be challenging for a farmer or land manager to balance risks and benefits of farm enterprise economics, soil health, and carbon sequestration or increases in soil organic carbon on varying scales of time.

As humans make decisions individually and within a social context, they weight past experiences and future expectations (Raedeke and Rikoon 1997). The perceived and desired timescale between decision, action, and outcome also varies between individual, social context, and type of decision. For example, a landowner may choose to employ soil cultivation to reduce weed pressure and dry up soil in anticipation for immediate planting. An adjacent landowner may choose not to use soil cultivation because they are anticipating longer-term compounding benefits such as increased soil organic carbon and soil water retention. These distant and often invisible benefits are considered to have epistemic distance—they are effects on a system beyond direct human perceptual capacity (Carolan 2006a).

The concept of inter-temporal choice and temporal distance has recently received attention from researchers (Milfront & Demarque 2015; Milfront et al. 2012; Wade-Benzoni 2008). Milfront et al. (2012:325) argue, "Time perspective seems to play an important role in influencing individuals' attitudes and behaviors towards the environment." However, as Berns et al. (2007:2) note, "The period between decision and outcome has received relatively little consideration from researchers because economic models typically do not treat purely mental events as intrinsic sources of utility." As a result, there is a lack of knowledge about how individuals plan and structure the timescales between decision, action, and outcome. For example, why do some people seem to behave on "shorter" timescales without regard for long-term consequences of their actions to themselves, others, or the environment? Why do some people behave on "longer" timescales in consideration to preserve resources for the sake of future use?

Because the study of time perception as it relates to environmental perceptions and agricultural decision making is still emerging, it is necessary to clarify definitions of terms to be used throughout this dissertation. *Timescale* is an umbrella terminology following the dictionary definition of "an arrangement of events used as a measure of the relative or absolute duration" (Merriam-Webster 2016). Timescales may occur, be observed, and anticipated in biophysical, social, and coupled human-natural systems. Following Milfront et al. (2012:326), *time perspective* implies "a person's experiences and conceptions of past, present, and future time." Time perspective thus connects the abstract concept *timescale* to the human system. Time perspective in this dissertation is segmented into two distinct components: (1) *temporal orientation* describes how humans consider the past, present and future in their time perspective, and (2) *temporal pathways* trace the ways humans perceive the "sequential occurrence of events" as either (a) cyclical or repetitive and/or (b) linear or sequential (Block 1990:25). The concept of *temporal reference*, as presented in Chapter 3, may be broadly thought of as how time perspective influences individual and group decisions and actions. In other words, the extent to which timescales are perceived to enlarge or constrain the "range of possible actions" and anticipated outcomes (Taddei, 2013:260). Agricultural decision-making results from a synthesis of considerations involving perceived timescales of environmental and human conditions.

Agricultural decision-making is a complex combination of environmental and social factors. Ibery (1978) describes three broad theoretical approaches commonly utilized in the study of agricultural decision-making: (1) assuming the natural environment controls decision-making, (2) assuming economic determinism or rationality controls decision-making, and (3) assuming neither environmental or economic factors alone control decision-making. This third category encompasses the study of values, attitudes, beliefs, risk perceptions, and social connections. McCown (2005) refers to this category as "subjective knowledge," which often involves unspoken and taken for granted forms of knowledge, such as cultural norms and historical narratives. He (2005:16) argues that advances or adjustments in “objective knowledge” are often approached through “normative interventions.” This involves the classical model of science communication—“Public understanding of science”—that seeks to simply provide more and better information. However, to achieve “Public engagement of science and technology,” in which end users are considered partners in the co-production of knowledge (Holden 2002), “facilitative intervention” may be more appropriate (McCown 2005). This allows for the acceptance of subjective judgement and preferences as “integral to real human decision making” (McCown 2005:16).

At the most basic, a decision which precedes an action results from beliefs about the world. These beliefs about the world are a function of "the agent's goals, his/her beliefs about the environment, and his/her beliefs about the envisioned tasks"(McCown 2005:23). In order to advance the process of facilitative intervention to advance agricultural decision-making for future climate adaptation, scientists need to recognize and accept that subjective beliefs, attitudes, and values impact the reception and utilization of scientific knowledge (Risbey 1999). Recognizing the complex values and knowledge systems that provide a lens to which farmers and others perceive science and climate change is a first step in understanding them. This dissertation seeks to explore the role of historical intergenerational family narratives and personally experienced past events in providing foundation for acceptance (or rejection) of advancements in climate and agricultural sciences for future resilience. The next section outlines conceptual inspiration for the development of this dissertation topic and the temporal reference framework.

Conceptual inspiration

This research project is the result of five years immersion into the community of scholars, practitioners, farmers, and other stakeholders seeking to understand the interactions among soil, water, climate, and agriculture. Several influential experiences throughout this process provided conceptual inspiration for the development of this dissertation and the temporal reference framework. The first experience involved leading a project to understand the capacity of state and extension climatologists to effectively communicate scientific information to agricultural audiences. Interviewing and surveying scientists with backgrounds in atmospheric science, meteorology, and climatology initially provided emergent themes surrounding the concept of time. It became very clear that the timescale in which climate and weather is researched and communicated varied greatly between individuals, research projects, and communication strategies. For example, climatologists study climate as past historical records which provide baseline measurements to contextualize current trends. Climate scientists, on the other hand, utilize their data to develop models for projecting long-term future trends. Atmospheric scientists often portray climate over geological period of time in units of centuries; state climatologists convey time on decadal scales in accordance with 140 years of National Weather Service data; and extension climatologists seem to focus on shorter scales of inter-annual and intraseasonal variability.

How these scales of time are framed and communicated seem to impact reception of the message among agricultural audiences. While attending the American Association of State Climatologists meeting in 2013, I followed up with individuals who had been interviewed and others that reflected on the process of communicating with agricultural audiences. A common theme emerged involving the timescale of contextualizing and presenting information. Several climatologists remarked how they often emphasized the meteorological aspects of their message, beginning any presentation by presenting short-range climate outlooks. One climatologist suspected he received much better reception from agricultural audiences when his background and expertise was listed as "meteorology."

Emphasizing past recent events and landmark years in communication strategies also appeared as another common theme. After attending many conferences, meetings, and workshops where various climate scientists conveyed information to agricultural audiences, the framing of time-scale in the context of climate and agriculture appeared to influence reception of the message. Individuals who begin their presentation with historical context, recent weather, and then transitioned into future climate model projections seemed to be well received. In contrast, individuals who immediately launched into future model scenarios with no contextualization for baseline measurements or explanation of what data drive the models appeared to resonate less with the audience. These presentations more often received critical or even hostile questions from audience members concerning climate policy and questioning the scientific consensus of climate change. Presentations which contained historical context seemed to more often result in audience engagement, productive questions, and discussion of positive contributions of climate science for risk management.

At several of these events, the most effective climate science communicators relayed the old adage that "Every farmer remembers three things: their best year, their worst year, and last year." This was evident in their presentations and messaging strategies, where years like the drought of 1988 and the flood of 1993 were mentioned and emphasized to provide context. The idea of analogous historical events as powerful narratives for information reception is a fundamental inspiration for the development of the temporal reference framework as described in Chapter 3. Another parallel theme that emerged throughout these involved the "generational frames" of time-scale.

The concept of what might be thought of as *intergenerational timescales of conservation* arose throughout these experiences and exposure to popular press and news articles as well as similar research projects. For instance, I assisted in developing educational modules for Natural Resource Conservation Service (NRCS) personnel around the topic of communicating climate science for agriculture. I was tasked with selecting and contacting three leaders in adapting their farm management practices for climate adaptation and mitigation. In the process of interviewing these farm leaders—one soybean farmer in Iowa, one dryland cattle rancher in western Nebraska, and one grape producer in California—a common theme emerged around intergenerational timescales of conservation. It was evident, as these leaders in climate adaptation articulated, that their decision process referenced not only their immediate individual success, but rather the long-range outlook of their natural resource base for the prosperity of future generations. They also discussed at length how these decisions often were in contrast to how previous generations had managed the farm and challenges associated with these changes. The concept of intergenerational timescales similarly emerged from a research project understanding motivations for conservation practice adoption among Iowa Farm Environmental Leaders in Iowa (Bates and Arbuckle 2016).

Threaded throughout these experiences and conceptual inspirations is the process of social learning. Social learning is the mechanism whereby humans develop knowledge through the process of observing others over time (Bandura 1977). Scientific information is only one form of knowledge; many other forms of socially-referenced knowledge are assessed when an individual considers potential outcomes of a decision. The concept of change inherently involves a deviation from some previous state, whether that may be average annual precipitation or the accepted normative behavior of a certain practice. Sociology has described how technological innovations which change historically-established practices (such as moving from open pollinated to hybrid seed corn) diffuse through communities (Rogers 2003). The "neighbor effect," as it has been referred (Roesch-McNally 2016), is anecdotally evident in rural communities and also appears in the literature.

For example, Bultena and Hoiberg (1983) examined how farmers adopted reduced soil tillage in relation to community-level perceptions of this practice. They measured perceived local acceptance of reduced tillage as percent of respondents who report half or more of their neighbors as favoring reduced tillage. Perceived local adoption of reduced tillage is reported as percent of respondents who report half or more of their neighbors as using reduced tillage. Their findings (Table 1.1) suggest that early adopters of reduced tillage perceived overwhelming local acceptance (96%) and adoption (79%) of this practice. On the other hand, non-adopters reported much less perceived acceptance (66%) and adoption (33%) of reduced tillage (Bultena and Hoiberg 1983).

Table 1.1. Characteristic of early adopters, later adopters, and nonadopters of conservation tillage (Adapted from Bultena and Hoiberg 1983).

	Early adopter (N=54)	Later Adopter (N=65)	Non-adopter (N=91)
Perceived local acceptance of reduced tillage	96 %	80 %	66 %
Perceived local adoption of reduced tillage	79 %	54 %	22 %

Other literatures suggest the prominent role of upholding and continuing family values and traditions of family heritage in the context of agricultural management (Salamon 1993; Neumann et al. 2007; McMillan 2015). However, much of the recent literature on farmer decision-making and conservation adoption focuses on beliefs and attitudes. It is crucial to acknowledge and understand the role of values in the process of scientific deliberation and knowledge development (Dietz 2013). A helpful metaphor is to think about attitudes, beliefs, and values as layers of the earth. Attitudes correspond to the thin outside layer—they are more often visible to others and open to change with exposure to new information. Beliefs represent the next layer underneath earth's crust. They are harder to observe, but guide how attitudes are formed and conveyed. Values are like the earth's core. They represent the primary foundation to which attitudes and beliefs are built and referenced. If an individual has a strong value system about a topic, it is very difficult to adjust their attitudes or beliefs about that topic. However, if an individual does not have a pre-established value system on a topic, their attitudes and beliefs towards that topic may be more malleable.

This is important because human value systems are developed in accordance with a self-identified social reference group (Kahan et al. 2013). This suggests that individuals assess those around them to develop their own attitudes, beliefs, and ultimately form values about certain topics. For most individuals, our first exposure to making sense of the social and natural world comes from those around us in the early stages of childhood development (Bossard and Boll 1960). Often times, the social reference group in which we self-identify at this stage in life are our family (Lamb 2014). As a result, family values provide the foundational core to which we develop attitudes and beliefs throughout the rest of life. This is evident in how first generation farmers—who would not have as strongly formed value systems about the practice of farming—differ in their management practices than multigeneration farmers and are suggested to be more open to change (Inwood, Clark, & Bean 2013).

It has been demonstrated that the public's perception of scientific consensus is a factor in the acceptance of science (Kahan, Jenkins-Smith, & Braman, 2011; Lewandowsky, Gignac & Vaughan, 2012). And these perceptions affect whether societal action occurs to address climate-related issues and implement climate policy (Ding, et al., 2011; Kahan et al., 2012; Rabinovich & Morton, 2012). Further, public engagement with science and technology research (e.g. Holden, 2002) suggest that the "deficit model," based on the public's lack of understanding of science, may not adequately address the barriers of integrating scientific knowledge to influence behaviors and support appropriate policies (Wynne, 2006). Particularly in the case of climate science, it has been suggested that a multitude of complex social factors influence the general public's reception and acceptance of scientific consensus, including values (Nilsson, Borgstede,

& Biel, 2004), emotions (Leiserowitz, 2006), and socially-reinforced perceptions (Kahan et al., 2011).

These experiences inspired the process of inductive reasoning to further explore the relationship of human generational time reference, climate, and agricultural soil management. The process of inductive reasoning starts with an empirical social reality or collection of data. Grounded theorizing is a technique utilized for conducting qualitative data analysis in which concepts are detected, developed, and refined (Charmaz 2006). This allows the researcher to move from data to the formation of concepts and empirical generalizations, allowing for the building of theoretical framework (Neuman 1994). Inductive research has been a formative process for theory development in rural sociology (Smith and Zopf 1970) and was utilized in the development of the temporal reference framework presented in this dissertation..

Time, climate, and agricultural soil conservation

In an effort to understand why farmers adopt production technologies, Nowak (1992) lists seven reasons for non-adoption. One of these reasons, “planning horizon is too short,” highlights the temporal dimension of agricultural decision-making. “[Crop] residue management systems may be rejected by a farm firm because of the current planning horizon relative to the time associated with recouping initial investments,” Nowak (1992:14) argues. As scientists and researchers, it is necessary to recognize the temporal reference of our science in the context of a farmer’s decision.

The concept of climate is often researched and communicated in terms of long-range scales of geological time. Climate is challenging for human perceptual capacity to comprehend within one human lifetime (Dahlstrom 2015). In contrast, many corn-based cropping systems are made on annual or monthly timescales (Takle et al. 2014). There are also benefits to withholding the option value of maintaining flexibility by delaying decisions (Lev & Campbell 1987). The consideration of time-scales by farmers in managing soil resources under changing climatic conditions is a crucial and currently understudied component of agricultural climate adaptation.

The inversion of soil, commonly referred to as soil cultivation or soil tillage, is a practice utilized primarily in annual grain crop production agricultural systems (Lal 2006). Management of soil resources through the practice of tillage is an applicable exemplary practice in which to consider and assess the interactions of time, climate, and agricultural soil conservation. For instance, no-till systems in long-term research plots may demonstrate environmental and economic benefits, but for the individual farmer who must purchase no-till drill equipment and experience an initial yield lag for a few years during transition, these long-term future benefits may not outweigh the farmer's available planning horizon. The following paragraphs describe how the practice of tillage relates to timescale of changes in soil conditions in relation to tillage practices, the process of scientific consensus throughout the last few decades, and the role of social learning and generational influence of land management.

Soil tillage is an important concept to examine relative to decision time perspective because biophysical soil condition responses to tillage techniques are inherently linked to timescale. Tillage techniques may involve tradeoffs between yields, soil quality, soil organic carbon, and soil water retention that are differentially expressed over varying timescales (Rhoton, 2000). For example, research has demonstrated that soil porosity may be increased by conservation tillage or no-till, but that this benefit may take from 3-7 years to be achieved (Voorhees & Lindstrom, 1984). No-till has also been shown to increase soil organic carbon and soil aggregate stability relative to conservation tillage techniques, although these effects are only realized over an extended time period (Al-Kaisi, Douelle, & Kwaw-Mensah, 2014). Outreach messages to agricultural audiences suggest that "tillage is a quick fix but it does long-term damage to soil" (Al-Kaisi 2014). The United States Department of Agriculture Natural Resource Conservation Service's educational series, "Bringing the science of soil health home," suggests that "While farmers have historically used tillage to prepare seed beds and to control weeds…Tillage ought to be a last resort, because it tends to be a short-term fix" (USDA NRCS 2016).

Following these observations, scientific findings have recommended against fall or post-harvest tillage (Karlen et al. 1994; Lal 1993; Mathews et al. 2012; Kumar et al. 2014). However, anecdotal evidence suggests fall tillage is still prominently utilized in soil and crop management systems. Social science findings indicate that influence of social norms and cultural traditions on tillage decisions (Carolan 2006a; Bell 2004; Carolan 2005; Wilson 2001) can perpetuate potentially maladaptive climate responses to wetter springs such as the action of fall tillage. By following the transformation of fall soil tillage recommendations as described in popular press for farmer audiences, it is evident that scientific advice for this practice has changed drastically within one generation.

Farmers Weekly Review is an influential newspaper established in 1921 and published in Will County, Illinois. In the heavy and often moist clay soils of the upper Midwest, the practice of fall tillage with moldboard plow was recommended and encouraged throughout advertisements and articles. For instance, a story published on November 9, 1972, "Factors guide fall tillage decision," suggests that "Fall tillage can give you a headstart on next spring's field work." It continues by recommending that "Fall tillage with a moldboard plow will often aid spring seedbed preparations, especially if the previous crop was corn."

Beginning in the later 1970's, this recommendation began to change. An article ran on December 3, 1981, "Fall tillage – a popular change," provides a rather different perspective than ever previously conveyed in the *Farmers Weekly Review*. It states, "Fall tillage with chisel plows is becoming popular. For years, it has been the practice for farmers to get the moldboard plow in the ground as soon as the corn is harvested." This suggests a deviation from the recommendation just nine years prior. This story concludes by offering advice that "When farmers try conservation tillage, they find out how this practice saves fuel and soil. Remember, petroleum and soil are non-renewable resources, let's conserve them."

The message around tillage changes again just seven years later. In a story run on November 24, 1988, *Farmers Weekly Review* provides their readership with the information that "No-till, a popular conservation tillage method that requires planting a new crop in the residue of the previous crop, is facing increasing evaluation as a result of this year's severe drought." This story continues to describe how "Some no-till corn withstood the drought better than conventional till. No-till looked better than spring plowed crops on similar soil and management conditions…. In average and limited drought years, no till generally results in better yields than conventional tillage." This information was conveyed just after the historic drought of 1988, which was a transformative event that is still referenced as an analogy by farmers today (see Chapter 2).

By December 14, 2006, the topic of soil tillage had changed drastically from the message original delivered in 1972. *Farmers Weekly Review* reported that "For the first time ever, the percentage of cropland planted with no-till has surpassed conventional tillage in Illinois, according to the 2006 Soil Erosion and Crop Tillage Survey. No-till rose to 33.1 percent of all

Illinois land planted with corn, soybeans, and small grains, while conventional tillage dropped by 31.2percent." Bob Frazee, University of Illinois Extension natural resources educator, "still recalls the days in the 1970s and 80s when no-till was just catching hold and 'many people called it a passing fad. Many felt it was never going to play out.'" The question remains, to what extent is the current practice of fall tillage a relic upholding the culturally accepted historical legacies of soil management in grain cropping systems?

One of the farmers interviewed for this study highlighted the complexity in how preferences for land management can become "preserved" in time. This Iowa farmer recalled how they were hearing a message that "what we should be doing is getting it back to how Iowa was and put it all back in prairie." The farmers responded, "How did they pick that time line? Why not the oak savannas? Why not when we were under water?" This is an insightful observation into how land management activities may seek to preserve and perpetuate an ecological state that is perceived as "correct." As Carolan (1996b) observes, such conceptualizations of natural systems are often portrayed as objective reality, but actually represent value statements. "This is not to deny the existence of the underlying reality the these claims speak to," Carolan (1996b:662) argues "but rather to highlight how these concepts rest on beliefs about what we think 'nature' should look like." Some argue the modern environmental movement seeks to sustain nature as "humans prefer it" by maintaining desired conditions and disregarding natural ecological transformations (Butman 2006; Morton 2007).

The preservation of natural systems in states which humans think they "should look like" is evident in forestry ecosystem management. For instance, there is evidence to suggest that oak savannah stands were actively cultivated by Native Americans for mast production through fire management and tree girdling (Abrams and Nowacki 2008). Reduction of large-scale fire management in the early 1900's facilitated establishment of more shade tolerant species, such as maple and basswood (Mikan et al. 1994). Research suggests that in contrast to our culturally-reinforced efforts for preserving oak savannah forests in the state during European settlement, these forest stands are not climax communities or represent steady state ecological conditions (Pederson et al. 2015; Millar et al. 2007). With annual precipitation in Iowa increasing 8% from 1873 – 2008 (Berendzen et al. 2011), ecologists anticipate natural forest succession from oak-dominated savannahs to species which are more shade and moisture-tolerant and transitioning to alternative ecological states (Millar et al. 2007; Beisner et al. 2003). Human impacts such as policy have similarly driven reduction of oak-dominance, which is often regarded by forest managers as undesirable (Knoot et al. 2015). As climate conditions change across the upper Midwest, to what extent are farmers preserving culturally-reinforced soil management practices regardless of potential adjustments in ecological states and climate conditions that provide early warning signal for adaptive response?

Research statements

This dissertation provides three distinct but related studies to explore the connections between time perspective, climate, and agricultural soil management. Each paper was prepared for publication in a peer-reviewed scientific journal to advance interdisciplinary research on the topic of timescales, climate, and agriculture. This research has broad applications for our understanding of conservation adoption, climate adaptation, and communicating climate science for agricultural audiences. An inductive research approach allowed for the development of a theoretical framework of temporal reference (Chapter 3). The temporal reference framework is then applied and tested in mixed-methods (Chapter 4) and qualitative (Chapter 5) analyses.

This chapter provides an overall introduction to the problem of understanding farmer decision-making relative to climate and agriculture, the gap in literature involving understanding of time and temporal reference, conceptual inspiration for inductive development of theoretical framework, and examples to introduce evolving scientific consensus on topics of soil conservation and soil tillage. Chapter 2 provides a detailed methodology to introduce the proceeding analyses.

Chapter 3 builds the temporal reference framework by employing the concept of historical analogies. Drawing upon farmer interviews (N=159), several concepts are extrapolated through inductive analysis of the qualitative data. The themes of time perception, social influence of decision-making, climate risks, and soil management are emphasized to discover how past personal experiences and historical intergenerational narratives are assessed to guide and influence current agricultural management practices. The concept of temporal reference is illustrated by providing empirical evidence from qualitative data and selected exemplary quotes from farmer interviews

Chapter 4 employs a mixed-methods design using data from the 2015 Iowa Farm and Rural Life Poll (N=1,159) and in-depth interviews with Iowa farmers (N=20). The research question asks: To what extent do previous generations and social norms influence soil conservation practices? This study particularly focuses on the reported increase, decrease, or no change in the practices of fall tillage, no-tillage, and cover cropping. Following suggestions in the agronomic scientific literature, a binary logistic regression is utilized to determine what factors are associated with decreasing fall tillage (relative to no change) and increasing no-tillage and cover crops (relative to no change). Building upon the temporal reference framework and the prominence of historical intergenerational legacies of agricultural management, it is hypothesized that social norms and pressures will negatively impact decreases in fall tillage and increases in no-tillage and cover crops.

Chapter 5 further parses the temporal reference framework to explore temporal orientation (future or past) and temporal pathways (cyclical or linear). This study extends beyond soil conservation and addresses topics such as climate change beliefs causality and conceptions of on-farm sustainability. This chapter explores the questions: How do upper Midwest farmers' temporal orientation and temporal pathways influence perceptions of climate change and sustainability? How does this compare to a sample of upper Midwest climatologists? It is postulated that socially-referenced past orientations dominate how farmers perceive climate change and agriculture. Further, building upon the literature described above, it is posited that socially-referenced temporal perceptions will evoke notions of time as cyclical and repetitive. A temporal reference matrix is constructed based on analysis of 159 interviews to determine in which quadrant upper Midwest corn farmers predominantly occupy in their assessment of changes in climatic conditions and adaptive management practices,. Twenty-two interviews with state and extension climatologists in the upper Midwest provide data to explore how climate scientists perceive climate causality and the intersection of climate and agriculture.

The concluding chapter (Chapter 6) provides a synthesis of findings across the three papers. This allows for the identification of implications, avenues for future research, and overall concluding remarks.

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CHAPTER 2.

METHODS

As part of United States Department of Agriculture (USDA) – National Institute for Food and Agriculture (NIFA) grant 2011-68002-30190 "Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems," this research seeks to understand farmer decision-making as it relates to soil, carbon, and water management in corn-based cropping systems under changing climate conditions. In particular, this research focuses on the role of time perspective, intergenerational influence, and social learning in the formation of knowledge systems for decision support. This study seeks to advance communication of agronomic and climate science to help assist farmers and land managers in remaining resilient and productive while minimizing soil erosion and off-farm nutrient leakages. This dissertation explores why and in what ways human behavior changes (or not) in response to advances in climate science and potential impacts from climate changes to agriculture in the upper Midwest.

A mixed-methods approach is employed utilizing random sample survey data from the 2015 Iowa Farm and Rural Life Poll and 20 Iowa farmer in-person interviews conducted in 2013. In this study, the mixed-methods approach utilizes qualitative data to complement and enrich quantitative model interpretation by providing quotations that help assure transparency and ground-truth results (Prokopy 2011). Quantitative data gathered through survey responses allow efficient and potential large sample sizes of information for analysis and modeling (Dillman et al. 2009; Neuman 1994). Qualitative interview data assists model interpretation by providing further explanation of results with in-depth and contextualized information (Neuman 1994; Prokopy 2011).

Quantitative data

The Iowa Farm and Rural Life Poll (IFRLP) is an annual panel survey of Iowa farmers conducted by Iowa State University Extension and Outreach in partnership with the Iowa Department of Land Stewardship and the USDA National Agricultural Statistics Service. The questionnaires were mailed to 2,093 Iowa farmers in February 2015 and 1,159 surveys were received for a response rate of 55 percent. Participants were 65 years old, on average, and farm an average of 441 acres. This sample of farmers is slightly older than the general farmer population and farm more acres on average, according to the 2012 Census of Agriculture. This research is supported by the Agriculture and Home Economics Experiment Station at Iowa State University. For more detailed survey methodology, see Arbuckle (2016).

Iowa Farm and Rural Life Poll question #11 (In general, how much influence do previous generation(s) of your family have on the way you currently manage the following aspects of your farm operation?) resulted from a conceptual development contributed by the author and two senior social science faculty. Response categories were developed with assistance from literature on family and agriculture decision-making (e.g. Salamon 2012). The survey instrument was pilot tested with a purposeful sample of 10 corn-soybean farmers located throughout Iowa, Minnesota, and Wisconsin. Feedback from these farmers allowed researchers to refine the question for inclusion in the 2015 IFRLP

Qualitative data

Qualitative data were obtained from a larger sample of semi-structured in-depth interviews with 159 predominantly corn-soybean crop farmers in the Corn Belt (see APPENDIX A). These interviews were conducted as part of a nine state collaborative effort to better understand farmers' perceptions about climate impacts to agriculture, use and perceived barriers to conservation practices, and sources of information (see Roesch-McNally 2016). In-person interviews were conducted by Extension educators and social scientists in the spring and summer of 2013 in Illinois (9), South Dakota (14), Missouri (16), Ohio (18), Indiana (20), Iowa (20), Minnesota (20), Michigan (20), and Wisconsin (22). This study was approved by Iowa State University Institutional Review Board (IRB) #12-473 (APPENDIX B).

Purposeful sampling of farmers connected to Extension networks resulted in a sample that may be considered more conservation-oriented. In other words, these farmers are more likely to have tried soil conservation management practices, such as no-tillage and cover cropping. This sample was selected to gain more information about challenges and benefits associated with conservation practice adoption. The sample is comprised of large-scale corn and soybeans commodity producers. Farmers with more than $100,000 in gross farm income in 2011 account for roughly 80% of the cultivated land in the North Central Region of the United States (Tyndall et al., 2015). Qualitative interviews were transcribed and analyzed using NVivo 10 (Nvivo 2014).

Eleven state climatologists and eleven extension climatologists (N=22) were purposefully selected to represent main outlets of location-specific and publicly available climate information throughout the upper Midwest region. Climatologists were contacted by e-mail, given details about the research, and asked to participate in the study. All 22 climatologists agreed to participate in the study. Interview protocol content revolved around (1) communication strategies to reach agricultural audiences, (2) perceived needs of agricultural stakeholders for weather and climate information, and (3) thoughts on barriers or facilitators for communicating climate science to farmers. Interview protocols and informed consent documentation were approved prior to administration by Iowa State University Institutional Review Board (IRB) #12-022 (APPENDIX C). See Wilke and Morton (2015a,b) for a more detailed methodology of the climatologist study.

Development of a qualitative analysis codebook allows for the calculation of inter-rater reliability while analyzing the farmer interview transcripts (see APPENDIX D). Analysis codebooks are also helpful to ensure objectivity of qualitative analysis and provide directions for study replication (MacQueen et al. 1998). This codebook enables researchers to quantify their coding of certain concepts mentioned in the transcript, allowing for direct comparisons among coders. Further, these quantified codes were statistically tested for significance to further ensure inter-rater reliability using the measure of Cohen's kappa (Cohen, 1960; 1968).

Utilizing the code book, each coder searched for nine themes. These themes were (1) Time (historical and recent past, present, future, (2) Social (family, friends, agency, informal and formal networks, social space), (3) Economic (crop prices, farm financial viability, crop insurance), (4) Geographic/spatial (farm field, watershed, nation), (5) Climate (precipitation, temperature), (6) Soil (water holding capacity, erosion, soil health), (7) Water (availability and quality), (8) Adaptive management responses (tiling, tillage, cover crop, crop rotations), and (9) Views of changes on the land (steady state, no change/dynamic, always changing). More specific information regarding the protocol for determining themes is available in APPENDIX D.

Inter-rater reliability data for interview coding by selected transcript is presented below in Table 2.1. Interviews were coded independently by a senior interdisciplinary social scientist and social science graduate student. Coding values for each theme were then compared and document to calculate Cohen Kappa Value. The average means of inter-rater reliability values presented in Table 2.1 are a range from 0.825 to 0.928. A respected figure in inter-rater kappa calculation, Krippendorff (1980) concludes that values greater than 0.8 indicate good reliability (Carletta, 1996). As a result, our lowest inter-rater reliability values of 0.825, 0.826, and 0.844 indicate good reliability of coding between our two interview transcript analyses.

Qualitative farmer interview protocol development, purposeful sample selection, and data analysis are further documented in Chapters 3 and 5. Quantitative survey instrument development, sample selection, and data analysis is further documented in Chapter 4.

Table 2.1. Inter-rater reliability data for interview coding for each transcript.

Transcript ID	Cohen Kappa Value
IA 10004	0.825
IL 17006	0.928
IN 18031	0.844
MI 26027	0.867
MN 27010	0.844
MO 29037	0.921
WI 55017	0.826

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CHAPTER 3.

ANALOG YEARS: CONNECTING CLIMATE SCIENCE AND AGRICULTURAL TRADITION TO BETTER MANAGE LANDSCAPES OF THE FUTURE

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Abstract

Climate scientists rely on observed historical weather and climate data to inform current and future climate model projections. Similarly, agricultural producers use historical events—recent past experiences and historical narratives—to construct local knowledge to assess, quantify, and manage current and future risks. These historical data, events, and experiences become reference points or analogs when compared to a current phenomenon that exhibits similar characteristics specific to past conditions. In this paper we utilize a lens of agricultural traditions and past experiences to posit a temporal reference framework. In-person interviews with 159 Midwest farmers illustrate how the past influences farmers' perceptions of current and future risks and is used to integrate scientific climate information to inform decision-making. Qualitative analysis provides support for the temporal reference framework, but more empirical testing is needed to further validate the model.

Introduction

Decisions about agricultural management, such as soil tillage, result in outcomes that are compounded across time (Lal, 2002; Grandy et al., 2006; Mathew et al., 2012). These actions can make the difference between retaining soil organic carbon to assure long-term productivity or losing soil to erosion and compromising agroecosystem services for short-term gain. Humans use feedback from past experiences and reference these benchmark events as "analogs" to inform current decision-making. Values and local knowledge systems are developed through a dynamic and continual process of social learning and act as a filter through which individuals perceive and act to address climate risk (Adger et al., 2009; Wolf et al., 2013). Social knowledge activates the experiential system which emphasizes relational timescales of past experience, while scientific knowledge activates the analytical system of linear or sequential timescales (Raedeke & Rikoon, 1997; Hautala and Jauhiainen, 2014; Slovic et al., 2004). Understanding how farmers perceive and use time as a reference to inform management decisions under increasingly variable climate and extreme weather events can help agricultural advisors and educators encourage effective adaptive strategies to reduce climate risks to agriculture and the environment.

Human perspective of time is an important predictor variable in environmental decision-making and normative behavior (Milfront et al., 2006, 2012; Coser & Coser 1990). Dietz et al. (2007:192) conceptualize temporal orientation as a causal variable and "stable, trait-like characteristic" in predicting support for climate change-related behaviors. Temporal references are shown to "have a determinant influence over what individuals and groups perceive in the world, how they construct their range of possible actions, and how they realize their existence" (Taddei, 2013:260). In agriculture, farmer perceptions of the risks that extreme weather and climate variability present influence decisions and actions which in turn can impact soil-plant-atmosphere interactions. The effects of tillage and other soil management practices are often not visible within an annual time cycle but accrue in time horizons of decades or generations. Similarly, the concept of climate, or the distribution of daily weather over time, is difficult for many people to interpret at human timescales and can influence understanding of climate change and subsequent decision-making (Dahlstrom, 2014; Milfront & Demarque, 2015; Weber, 2006; Weber & Stern, 2011; NASA, 2005). Thus, farmer perceptions of time play an important role in assessment of current options and the kind of strategies needed to adapt to changing weather and climatic conditions.

Jackson et al (2010) identify time as one of three types of scale used to evaluate and plan for sustainability of agriculture into the future. They propose a hybrid sustainability concept that combines sustainability—the meeting of current needs without compromising the needs of future generations—with the flexibility of adaptive capacity. The temporal framework presented by Jackson et al. (2010) is intended to represent planning for future uncertainty and risk and the rapid pace of human-induced environmental change. Along the time axis, efficiency dominates the here-and-now while longer term planning is focused on adaptation to future risk and continuation of agroecosystem functioning. They propose that farmer management decisions at many scales are primarily driven by private benefits "now" that generate economic returns. What this model overlooks is the past and how past experiences and historical narratives influence decisions in the "now" and can change perceptions of adaptive management alternatives. While much of our knowledge about sustainable behavior is future-oriented, it fails to recognize the contribution of past experiences and historical narratives that signal reactional or responsive adaptation to address future climate risks (Jackson et al., 2010; Darnhofer et al., 2010; Raedeke & Rikoon, 1997; Riley 2008). As time progresses, current decisions and experiences become the benchmark or analog to which future decisions are referenced and weighted.

This research addresses the gap in how time is theorized as it relates to agricultural decisions within the coupled human-agroecosystem at the farm-scale level. Time is conceptualized as a key variable that guides farmer decision-making and normative behaviors. A decision timescale framework is synthesized and built from several literatures, and then truncated to amplify the recent and historical past as feedback that guides farmer decision-making in the here-and-now. A temporal reference model is then developed to conceptualize the iterative and dynamic nature of social learning that occurs as recent past experiences and outcomes as well as intergenerational narratives are brought forward to inform a current decision point. Interview data gathered in 2013 from 159 Midwestern corn farmers are used to illustrate, refine, and provide empirical evidence for the model in preparation for future model testing. Following a presentation of results from in-person interviews, a discussion of model application elaborates how the past influences current farmer decisions. We conclude by suggesting the concept of temporal reference frames communication techniques which provide analogous or historically-referenced and socially relevant information. By talking about agricultural risk trends over a timescale that encompasses the past as well as the future, scientists may more effectively convey useful and useable agricultural climate risk information.

Temporal reference in climate and agriculture

Agricultural production in the United States Corn Belt is increasingly vulnerable to risks from extreme weather events and changing climate conditions (Walthall et al., 2013; Hatfield et al., 2014; Challinor et al., 2014). Adapting farm practices to reduce the threats of future climate risks requires adjustments in current grain cropping management systems (Hatfield et al., 2011; Howden et al., 2007; Delgado et al., 2001). Climate science can provide decision support to help agricultural producers adapt to environmental risks from extreme weather events and climate variability (Takle et al., 2014; Wilke and Morton, 2015). However, farmers and other agricultural decisions makers have been reluctant to accept and utilize knowledge of climate science to inform current and future land management decisions. This barrier to effective climate risk communication is exacerbated because decision-makers may not perceive scientific climate information and data as usable to inform decisions (Lemos and Rood, 2010; Briley et al., 2015). As Palmer (2002:5) notes, “Facts, figures, and future projections on the biophysical impacts of climate change or energy production have had far less of an effect” than many scientists had hoped. Thus, it is important to identify factors that may inhibit or obscure the transfer of knowledge from researchers to decision-makers in the context of climate and agriculture.

Several lines of research suggest the importance of temporal reference and the role of past experiences with weather and climate. Ingram et al. (2013:267) study the adoption of sustainable agricultural management and observe that “incorporating a temporal dimension into the wider question of farmers’ participation in agri-environment schemes can help to improve understanding of farmers’ behavior.” Adger et al. (2009:346) explore social limits to the adaptation of climate change and conclude that “historical and current adaptation is and continues to be informed by perceptions and local knowledge based on previous experience of weather and climate.” Further, they suggest that “it is unclear how insights from the past could serve us in the face of future climate changes.” Haigh et al. (2015:29) similarly conclude the need for “further investment in the use of historical climate information to quantify potential climate risks for agricultural decision makers." This research strongly suggests that temporal dimensions, particularly historical narratives and past experiences, play a prominent role in reception of climate risk information and agricultural decision-making.

While there have been numerous studies on adoption of science-based farm management practices (e.g. Baumgart-Getz et al., 2012; Prokopy et al., 2008), there is a lack of variables which reliably predict how farmers accept and utilize climate and agronomic science to inform crop management strategies for climate risk adaptation. Previous research suggests that experiential/subjective knowledge and experimental/objective knowledge are differentially weighted as individuals consider decisions about the natural environment (Raedeke & Rikoon, 1997). Studies to understand decision-making among the farming population have largely taken an atemporal approach and have inadequately evaluated motivations for short- versus long-term farm management (Darnhofer et al., 2010; Riley, 2008; Reimer et al., 2014). Further, the role of an individual's time perspective, or the guide of current action differentially influenced by past experiences and perceptions of the future, is not well understood (Dietz et al., 2007; Raedeke & Rikoon, 1997; Anderson, 2013). As a result, there is currently a gap of scientific knowledge regarding the role of time perspective, particularly of past personally experienced events and intergenerational narratives about climate risks in farm management decision-making. A temporal reference framework representing past personal experiences and historical narratives is proposed to explore the influence of the past on current agricultural and land use management decisions associated with risks from weather extremes and climate variability.

Theory

Conceptualizing climate and time

The idea of analogs—something similar to or analogous to something else—is a useful heuristic to understand and conceptualize interactions between climate and time. Analogs act as benchmarks or reference points to which current and future climate risks are compared and assessed. For example, while considering the potential risks of a flood warning, one might recall personal past experiences and stories of others in similar situations to help inform personal vulnerability and the urgency (or not) to act in particular ways. In this case, if an individual has little or no experience or first-hand knowledge of flood risks, s/he may underestimate or substantively overestimate the extent of the risk. On the other hand, if flooding has been a common occurrence, the impact of past floods can be used as a benchmark for whether the current situation presents a greater or lesser risk comparatively. Thus, similar past events offer an analog to the present and influence perceptions of risk and available adaptation options.

Under global warming scenarios, the possibility of summers in Illinois to "feel like current summers in Texas or Oklahoma by the end of the century" is something that has not yet been experienced (USGCRP, 2009:117). However, there are benchmarks or historical analogs for similar types of environmental conditions and climate risks that can inform impacts and adaptive alternatives in response. For example, a multi-year, prolonged drought in the 1930's across the U.S. Great Plains created an agricultural disaster of unprecedented magnitude. Prior conversion of prairie grasslands in a dry climate to cultivated row crops changed the seasonality of land surface vegetation coverage and resulted in the loss of perennial plant roots which held soil in place year around. Combined with drought and heat, this created conditions for wind erosion and extensive loss of top soil. The Dust Bowl, as it would come to be known, forced farmers to realize adjustments in common tillage and land use practices were needed. As the soil laden dust blew from the Midwestern fertile agricultural soils eastward towards the White House, Congress acted to establish the Soil Conservation Service in 1935 to address the management of soil and water resources under variable and extreme climate conditions.

Over time, however, new climate and weather analog events occurred, updating social knowledge of extreme weather impacts on agriculture. The drought and heat wave of 1988 that caused $40.2 billion in damages was a transformative event which created a new benchmark for drought events. In 2012, another historic Midwestern drought evoked memories of the late 1980s and Dust Bowl, becoming the new normal to which future climate risks of drought are compared. These experiences and narratives of drought risk are important for guiding current and future risk perceptions. For example, when asked about concern of agricultural climate risks, a majority of corn farmers in the North Central Region in 2012 reported they were most concerned about "longer dry periods and drought" (Loy et al., 2015).

Perceptions of other agricultural climate risks, such as excessive water, are also evaluated and updated in reference to analogous transformative events. The "Great Flood" of 1927 displaced nearly one million people in the Mississippi River Basin and is regarded as transformative in shaping American's political, agricultural, and ecological landscape (Barry, 2007). Ten years later, the "Great Ohio and Mississippi River Flood of 1937" resulted from a prolonged period of early snow melt and high precipitation and covered more than 200,000 square miles with water depths above 11 inches (Welky, 2011). This "thousand year flood" was the benchmark event in the region until summer 1993 saw "unprecedentedly persistent" precipitation throughout the Mississippi River Basin (Kunkel et al., 1994). The flood of 1993 then became the new analog flood risk event to which current and future climate risks were assessed. In subsequent years, 2008-2010, the Ohio and Mississippi river valleys experienced a series of years with excessive precipitation and flood disasters to which personal memories and stories of the 1993 flood were compared (Olson et al., 2011). Then another "great" flood in 2011 occurred, breaching levees and flooding agricultural lands at the confluence of the Ohio and Mississippi rivers (Olson and Morton, 2012a;b). Farmers, landowners, and the US Army Corps of Engineers compared this flood to the 1927 flood to make sense of its magnitude and impacts. These examples illustrate how experiences and narratives of flood and drought and their outcomes are continuously updated as current events move backwards in time and become historical benchmarks for similar current events.

Building the conceptual framework

Perception of time and temporal horizons are influential in the creation of knowledge and subsequent decision-making (Hautala and Jauhiainen, 2014). Previous research finds that humans utilize a "temporal fulcrum" in the creation of knowledge to evaluate both historical outcomes and expectations for the future (Raedeke & Rikoon, 1997; Riley, 2008). According to Reimer et al., (2014) temporal scales are critical "in assessing the outcomes of individual conservation behaviors and long-term landscape interactions," but have not received much attention. We propose an expansion of the temporal fulcrum and construct a framework from which to examine farmer decision-making in the context of climate risks and agricultural management.

Our decision timescale framework elaborates a temporal model by utilizing the work of Jackson et al. (2010) and expanding the timescale to encompass the past. The Jackson et al. (2010) model frames decision-making in agricultural systems across multiple scales (spatial, temporal, and institutional) beginning at "now" and moving forward in time. Their scientific lens of conservation behavior and land use adaptive management focuses upon future-orientated behaviors and decisions. However, the influence of the past remains a gap in our knowledge about the relationship of the temporal scale to management decisions. There is a need to better understand human orientations to time, the role of past historical legacies and how the past is continuously referenced and contextualized as a feedback mechanism within the spatial dimensions of social-human-natural systems.

The Decision Timescale Framework, Figure 3.1, identifies five distinct time markers thought to influence decision-making: historical past (more than one generation ago), recent past (current ancestral generation), current "now", immediate future (current descendent generation), and distant future (future generations). Each of these time markers can be sources of social/economic and biophysical feedback which differentially amplify or attenuate perceptions of risk and subsequent adaptive decision-making (Pidgeon et al., 2002). These timescales are contextualized with a geographic scale that is influenced by extent or scope of individual observation (Atwell et al., 2009; Bourdieu, 1998). Immediate and long-term future perceptions of social and biophysical risks are conceptualized as individual perception of future climate risks and time perspective regarding impacts of current decision and actions. Historical and recent past social and biophysical experiences are defined as experience with environmental hazards and intergenerational narratives about hazards to farm enterprise and management decisions.

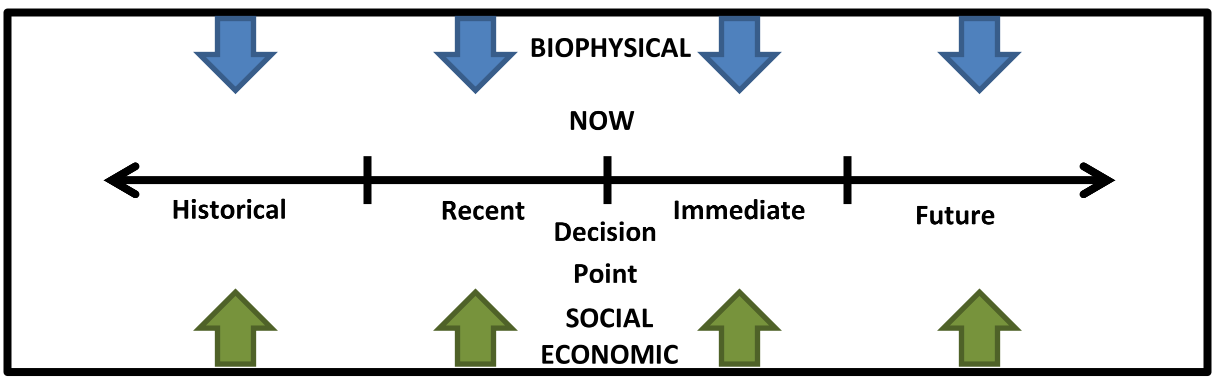

Figure 3.1. *Decision Timescale Framework. Decisions involve the consideration of multiple scales including temporal, spatial, biophysical, and social. This conceptual model posits decision-making as influenced by five time markers: historical and recent past events, current "now", and immediate and future outlooks.*

To fill the gap in the model proposed by Jackson et al. (2010), this research focuses on two distinct time markers: the historical and recent past. Historical past social/economic and biophysical experiences are defined as intergenerational narratives or stories that are passed through individual and family networks. Recent past social/economic and biophysical experiences are defined as those which have been personally experienced within the decision-makers lifetime.

Two distinct knowledge systems are activated in cognitive processing that result in decision-making and action. The first represents logical, rational, or analytical systems while the second represents emotional, affective, or experiential systems (Slovic et al., 2004). The analytic system is referenced by scientific knowledge that is learned through institutional channels. The experiential system is referenced by socially learned knowledge acquired through individual experience and interaction. These two distinct systems of cognitive processing parallel perceptions of temporal horizons: (1) Linear time is perceived as events having a logical and sequential order, while (2) relational or social time is perceived to be influenced by reference to social relationships and groups (Hautala and Jauhiainen, 2014). In other words, climate change-related behaviors, decisions, and actions may activate rational "reasoned and deliberative" responses and/or affective "habituation or automatic" responses (Fielding et al., 2014:415). Historical intergenerational narratives about climate and agricultural risks and past personally experienced climate and agricultural risks are not processed as linear time but activate the affective or experiential systems of risk perception. This affective system of risk perception can result in automatic or habituated decisions and actions in response to uncertain future risks.

The temporal reference framework posits that personally experienced past events and historical generational narratives have significant influence in affective risk perceptions that inform assessment and adaptive response to climate risks. Outcomes from past personal experiences and historical intergenerational narratives are used to inform current decision points. Previous outcomes that are analogous or similar in characteristic to current decisions affect how the event is weighted and processed as information used to guide decisions and behavior. Better understanding of the temporal reference can help scientists further explore the role of experiential processing, social knowledge, and socially-referenced time as it relates to the reception of climate science and applications to agricultural management.

Figure 3.2 illustrates the dynamic nature of the basic feedback loop process within the temporal reference model in which "now" decisions points (DP) are compared to past situations and decisions and their resulting outcomes. The temporal reference model hypothesizes an iterative relationship among past experiences and outcomes as decision points are assessed and acted upon over time. Time is conceptualized as a dynamic influence in decision-making in which multiple outcomes and experiences in the past, including personal experience and intergenerational narratives, inform a "now" decision.

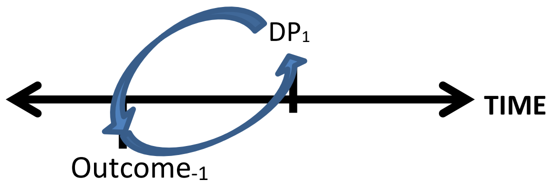

Figure 3.2. *Temporal Reference Model with basic feedback loop. Outcomes from past personal experiences and historical intergenerational narratives are used to inform current decision points (DP). Previous outcomes that are analogous or similar in characteristic to current decisions are given greater weight or importance when assessing potential decisions and action.*

Figure 3.3 depicts the iterative and dynamic nature of the temporal reference model. In this model, decision-makers are posited to reference multiple past timescales, including past decisions made and outcomes. The solid lines indicate personally experienced events, while the dotted lines indicate intergenerational narratives about events. Analogous past outcomes and experiences are then synthesized by the decision-maker to guide perceptions of and decisions associated with current situations. Some events or experiences may be interpreted as transformative, which influence cognitive and emotional assessment of risk. As a result, the balance of risk and benefit in subsequent decisions may be skewed to favor specific outcomes and not others. In this model, decision makers reference back to multiple timescales and outcomes, including both personally experienced events and intergenerational narratives of events. These past outcomes and experiences are synthesized to guide knowledge and perceptions of future outcomes.

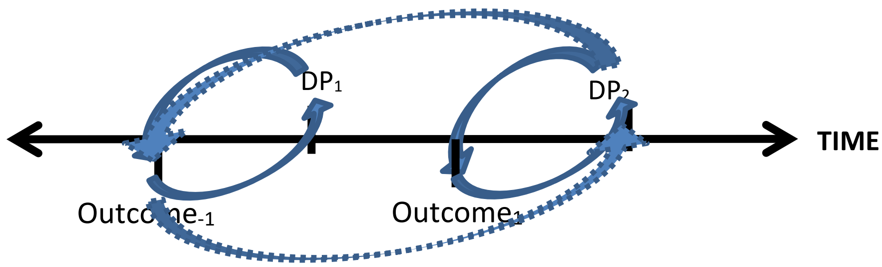

Figure 3.3. *Temporal Reference Model. Outcomes are given different weights based on perceptions and meanings assigned to the past and their impacts. In this model, decision-makers reference back to multiple timescales and outcomes, including both personally experienced events (depicted by solid lines) and intergenerational narratives of events (depicted by dotted lines).*

Recent past personal experiences

Recent past personal experiences are defined as events which occur within a human lifetime and are directly experienced by an actor or decision-maker. The theory of planned behavior, for example, highlights the principle of compatibility and suggests that the advantage of a behavior is perceived and assessed relative to past experiences of that behavior (Poliakoff & Webb, 2007:247; Ajzen, 2002; Ajzen, 1991; Ajzen & Fishbein, 1980). Past experienced events have consistently been found to influence perceptions of climate-related risks (Arbuckle et al., 2014; Arbuckle et al., 2013a; Morton et al., 2015). For instance, in a study of California farmers, it was found that climate change attitudes are strongly predicted by past experiences with particular policies (Niles, et al., 2013). Exploring soil conservation in Switzerland, Schneider et al. (2010:336) conclude that in “adopting no tillage, farmers have to fundamentally reconstruct their existing practices, experiences and concepts.” Similarly, Thomas et al. (2007:892) reviewed 40 years of no-tillage farming in Queensland and concluded that “evidence of such advantages associated with no-tillage was generally anecdotal, based on farmer experience.” This suggests that individual experiences act as analogs to which current decisions are compared.

Climate risks are perceived using a lens of influence which includes objective experiences of extreme weather and other social factors (Cutler, 2015). In the US upper Midwest, researchers found personal experience with excess water and saturated soils is significantly associated with use of drainage, tillage, cover crops, and planting on highly erodible land (Morton et al., 2015). Both analytical and experiential processing may be activated to codify experienced risks and cognitively decide to avoid or address them in the future (Slovic, 2000; Slovic et al., 2005). However, it has been suggested that risk perception may be amplified or attenuated by "social stations of amplification" (Renn et al., 1992; Pidgeon et al., 2002). After a transformative hazard event occurs, information of that event flows through social communities over time via news, conversation, and stories or narratives. In this case, social norms that impact descriptions and understanding of the hazard influence perceptions of the event characteristics, appropriate interpretation and behavioral response, and potential future impacts (Renn et al., 1992). Understanding social norms and symbolic narratives that influence risk perception over time can help connect risk perception to more quantifiable variables (Greiner et al., 2009). Of particular interest in rural agricultural contexts are the role of family structure and the transfer of stories pertaining to climate risks in the form of intergenerational narratives.

Intergenerational narratives

Several factors influence how individuals and groups perceive climate risks and subsequently guide agricultural decision-making and actions (Arbuckle et al., 2015, 2014, 2013b). One factor that has received attention in agricultural management is the role of family and intergenerational values (Salamon, 1992; Salamon et al., 1986, 1997). Family influences are important to understand because they impact a number of farm management practices in ways that are not well documented (Hildenbrand & Hennon, 2005). Further, the utility of a decision may include consideration of a resource's bequest value, or the value of preserving natural resources or cultural heritage (Fisher et al., 2009; Greenley et al., 1981; Frederick, 2006). Family history provides a blueprint for action and can influence "path dependence" to reinforce traditional decision processes that adhere to social norms (Inwood et al., 2013:363; McMillan, 2015).

Family narratives about the farm's history, traditions, and trajectory into the future appear to have prominent influence in current decision processes. Narratives are often constructed and transferred in the form of stories, traditions, and culturally-reinforced mutual understandings which shape identify and normative behavior (Loseke, 2007). Historical narratives allow for current management decisions to be "grounded in the farm's history, past activities, and traditions" (Ingram et al., 2013:277). Intergenerational perceptions of land use and succession have been shown to conflict with economic incentives and conversion of land use to non-traditional crops (Neumann et al., 2007; McMillan, 2015). For example, farmers with stronger family farm values are more resistant to converting farmland for alternative uses (Neumann et al., 2007). Symbolic meanings that reinforce traditional cultural practices and inform farmer knowledge can perpetuate normative action by sustaining fear of social disapproval or disgrace of family legacy (McMillan, 2015).

In the Midwestern US, Salamon (1992) has contributed a large body of knowledge to the understanding of household level variables and the influence of intergenerational transfer of narratives in agricultural decision-making. Anthropological analysis of Yankee and German families in central Illinois during the 1980s provide evidence that family traditions and norms dictate management decisions concerning intergenerational succession to farming, land tenure, and adoption of sustainable farming systems (Salamon, 1993; Salamon et al., 1986, 1997). It is suggested that family-level factors are important to farmer's perception of proper farm enterprise management, and that these factors may be sustained and perpetuated through intergenerational narratives about farm management (Salamon, 1992). Time perspective portrayed in these family narratives is also influential in land management. As Salamon (1993:582) explains, "how land is handled reflects what farmers consciously want to reproduce for the future and maintain from the past."

The role of intergenerational time perspectives in natural resource conservation is challenging for collective decision-making and policy development because there are many conflicting ways to consider decision timescales (Thompson, 2004; Boersema, 2001). Our research follows previous work presented by Field & Burch (1988) and applied by Salamon (1992) in conceptualizing time as a unit of analysis at the household level of a family life cycle. This allows for measurement regarding the role of intergenerational family narratives in developing perception of current and future risk and positioning farm management decisions within time frames or stations of influence. Time perspective may either reinforce or refute intergenerational "cultural legacy" or symbolic narratives that act as barriers or facilitators of agricultural adaptation (McMillan, 2015:50).

Data from 159 Midwestern US farmer interviews are used to test and refine the Temporal Reference Model (Figure 2.2). Themes of time perception, social influence of decision-making, climate risks, and soil management are emphasized to discover how past personal experiences and historical intergenerational narratives are assessed to guide and influence current agricultural management practices. The concept of temporal reference is illustrated by providing empirical evidence from qualitative data and selected exemplary quotes from farmer interviews.

METHODS

Data were gathered from in-person interviews with 159 farmers conducted in 2013 in the North Central Region of the United States. Geographic representation of interviews included Wisconsin, Indiana, Iowa, Minnesota, Michigan, Ohio, Illinois, South Dakota, and Illinois. Purposeful sampling of conservation-oriented farmers occurred through recruitment by land grant university extension educators. Participating farmers are large-scale commodity producers who grow corn and soybeans. Corn farmers with more than $100,000 in gross farm income in 2011 account for approximately 80% of the cultivated land in the region (Tyndall et al., 2015).

Farmer interview prompts and questions were developed collectively by a team of social and economic scientists involved with the Climate and Corn-based Cropping Systems Coordinated Agriculture Project (CSCAP) project. Extension educators also provided input on question prompts and assisted in conducting interviews in their local regions. Interview protocol involved sections on conservation (emphasizing nutrient management, cover crops, and tillage), experience with weather variability, beliefs about climate change, sources of climate and agronomic information, and attitudes about agricultural sustainability. This study was approved as exempt from Iowa State University Institutional Review Board #12-473.

This purposeful sample of farmers tends to be more conservation oriented than average Midwest corn farmers. They are early adopters of conservation practices and more than half are currently using or have tried cover crops and no-till. A primary rationale for recruiting these farmers was to reach individuals who had some exposure and experience with key conservation practices (e.g., precision agriculture, no-till, cover crops) and who may have surmounted barriers or experienced challenges when adopting these practices. This sample of farmers may also have direct exposure to and experience with climate risk information and its usefulness and usability for farm management planning. Family members and farm partners were also invited to participate in the interview session if they desired. For a more complete and detailed description of methods, see Roesch-McNally (2016).

Interviews were transcribed, analyzed line-by-line and coded for major themes. NVivo qualitative analysis software assisted in coding and quantifying themes (NVivo, 2010). Development of a qualitative analysis code book (APPENDIX D) guided analysis and assessment of concept frequencies to further refine and parse concepts (MacQueen, 1998; Miles, 2014). Conceptual themes that were analyzed include: (1) Time (historical and recent past, present, future, (2) Social (family, friends, agency, informal and formal networks, social space), (3) Economic (crop prices, farm financial viability, crop insurance), (4) Geographic/spatial (farm field, watershed, nation), (5) Climate (precipitation, temperature), (6) Soil (water holding capacity, erosion, soil health), (7) Water (availability and quality), (8) Adaptive management responses (tiling, tillage, cover crop, crop rotations), and (9) Views of changes on the land (steady state, no change/dynamic, always changing). Two social scientists independently coded a subset of seven randomly selected transcripts to ensure inter-rater reliability. For each of the transcripts, Cohen's kappa reliability scores were greater than 0.825. The focus of this analysis examines the interaction among the themes of time, social, climate, and adaptive soil management.

Results

Time perspective

The weather and climate are on farmer's minds. Qualitative interview analysis reveals farmers connect climate and past weather events with the concept of time. While weather is a daily, short term experience, climate is the aggregation of average weather over time (NASA, 2005). Changes in climate may not be directly experienced in one human lifetime and are difficult to understand at human scales of perception (Dahlstrom, 2014). As a result, climatologists often face challenges in communicating the implications of climate science to agricultural audiences (Wilke and Morton, 2015).

Historical observations of climate were frequently perceived by the interviewed farmers to mirror future trends. This is articulated by a Missouri farmer, who comments, “The climate historically has always changed from the beginning of time, and I think it will always change as we trend forwards” (29037). He continues this thought with the observation that “I don’t think that humanly we can control the climate.” This theme was common across the interview transcripts. When asked about their opinions on climate change, more than 75% of the farmers responded with some reference to the past, historical events, or cyclical changes. This suggests that historical observations of weather and climate are used as a benchmark or analog to influence perceptions of future changes.

Another time theme throughout the transcripts involved the interplay of short- and long-term decisions. A Minnesota farmer discussed the time frame of agricultural decision-making as a much shorter time frame and suggested that farming sustainability and success were measured by whether “you're still around for next year to farm” (27007). A Missouri farmer elaborated on the time aspect of decisions: “I mean, if you look at a lot of farming operations, [they] are not short-term decisions” (29037). This farmer goes on to indicate that “our operation is probably five-, ten-year decisions…we’ve made a decision we’re going to try and do something—it may be ten years before we get it done and over.” These comments indicate that farmers are thinking about their decisions along a timescale which varies between individual farmers and certain decisions.

An Indiana farmer made a more specific reference to shorter timescales: “I can say I'm going to feed the world but, right now, I just want to put money in my pocket so I can pay my bills… That's a short range look, selfish look, but that's me” (18013). This suggests that while time is an important construct in which climate and agronomic decisions are referenced, multiple timescales may be considered for different farmers. The same farmer continued with an analogy that illustrates conflicts of crop and livestock growth time-scales. “I [have] got to be looking relatively short term, cash turnover, you know. Particularly on 75 acres. I'm renting that farm so the guy that I'm renting the farm from expects money every year. So I can't go out and plant walnut trees all over this and, you know, and try to raise squirrels for their hides.” These remarks suggest discrepancies between annual timescales of crop production and multi-year scales of livestock production. The farmer is joking about the inability to make long-term management plans because of the economic realities of annual crop land rental.

Recent past personal experiences

The role of past personal experience is another prominent theme that was evident throughout the transcripts. For instance, an Iowa farmer remarked, "This year, we're plenty cool so I can't say that we're into global warming because we've experienced enough cool years in the last 5 years also" (30101). This experience of cool years leads the farmer to continue with the conclusion, "I'm not a big believer in the global warming thing and climate change." A Michigan farmer illustrated how experiences with yield mapping influence nitrogen management decisions. "We've had yield mapping here since 1995…so we can look at trends and things like that and put realistic goals in for nitrogen" (26024). A farmer from South Dakota described how the drought impacted tillage management: "After the drought of 2012...maybe we should do something different. Maybe we should quit running machinery, burning fuel, you know, over these fields. Maybe blacker [soil] isn't always better" (46012). Experiences of climate and agricultural management risks are often depicted as rational for decision-making, as this Minnesota farmer describes:

> "We'd go till the ground, whether it was a plow or chisel plow or what have you, and the creek would come out and flood and we saw that we were losing significant amounts of soil. So what we decided to do was, we didn't take any government program, there was no program of any kind, we just decided that we're going to seed this down into grass" (27012).

Personal experiences with soil management are also perceived and acted upon by different generations. The following observation from another Minnesota farmer illustrates how previous generations can act as gate keepers to reinforce a "cultural legacy" or status quo of soil management decisions.

> "My dad was adamant we had to do some tillage. And one year we had ... on his farm has kind of a small hill that's kind of light ground and I thought, well, if I

> work this, it's going to blow in the spring. And when I was drilling it, of course, it's kind of rough… Where we hit that spot, it was so nice and smooth; it was like driving down a highway. And I got out and kicked in the dirt and it's nice and soft and mellow. You walk back where that heavy disk went, it was clotty; it was hard. And I, actually, had him [dad] drive out to the field. I said, come here and look at this. And we were walking back where I had drilled and we was on this hilltop and he said, don't go so fast, I'm twisting my ankle. And I said, exactly, that ground's hard as a rock… You walk back here and you're kicking the dirt and nice and mellow. He said, ya, just do what you want, and he left. So that's when we switched completely to no-till." (27007)

Regional comparisons of agricultural production in relation to experiences of extreme weather events also signaled changes in soil management. This Illinois farmer describes how they adopted no-till after more than 20 years of conventional tillage after the droughts of the late-1980s.

> "We continued with the conventional tillage until 1989. '88 was, of course, the nationwide drought year. '89 here was even a worse localized drought year. So we decided to take a real serious look at the way we were doing business because there was a fellow that was doing no-till right next to us and he'd already been in the process 10 years and it was, basically, in its infancy then, you know. There wasn't a lot known about it but he was killing us on yields, probably doing 30-40 bushel better than we were" (17005).

Intergenerational narratives

The concept of sustainability is linked to timescales which encompass multiple generations. A commonly used definition describes sustainable actions as those "which meet the needs of current generations without compromising the ability of future generations to meet their own needs" (United Nations, 1987). Therefore, stories or narratives passed down through generations to depict historical events, traditions, and norms are important to understanding the relationship between time perspective, climate, and sustainability of the farm.

Mentions of relics and symbols of the past that were referenced to assess perceptions of current and future changes are evident throughout the farmer interviews. For instance, an Indiana farmer responded to a question of changes in climate by remarking, "I'm not sure how much things are actually changing. I wish I had a dinosaur around to ask him, you know, what kind of changes I should be looking at" (18013). Reference to the historical past is also evident in farmers' understanding of inter-annual weather variability. "They have, like, average temperatures, average weather and there is no such thing... It's an average of the extremes, you know. Like we come off such a dry year and now we're wet. I think that's just probably the way it's been a long time" (30101).

The theme of intergenerational narratives is conceptualized by references to the historical past in relation to generational or family contexts that influence decision-making. This concept is exemplified by the following remark from an Indiana farmer (18013): "Who in the hell is not trying to sustain a living? And sustain the farm? So, why, all of a sudden, is this [sustainability] a new concept? Do you think my grandfather, my great-grandfather; my great-great-grandfather didn't try to sustain a living? So this term, as you can tell, seems completely worthless to me. So that is my answer to sustainable agriculture." A Michigan farmer remarked about the pressure imposed from previous generations: "It's tough to buck tradition…this is how we do it, this is how grandpa did it…there's peer pressure" (26028). Another farmer described generational resistance to changes in agricultural management: "It was a big change to think about doing it that way, you know, because dad and grandpa hadn't ever farmed that way" (27008).

Another Indiana farmer elaborated on the importance of family members and intergenerational transfer of environmental perceptions that are brought forward in relation to time: "We all learn from our peers, whether it our mothers and fathers or our aunts and uncles or whatever. So sustainability's something that you want to pass on to your blessings, so to speak" (18018). A Minnesota farmer exemplifies how long-term agricultural sustainability may be thought of as continuing the operation as it is today. "I would say a long-term sustainability, to me, as a fifth generation producer, would be a steward of the land, to continue the farming operation as we know it today" (27010). This same farmer continued to remark, "It's something that you take a lot of pride in, as the fifth generation. You assume some of the things, prior to, were done right otherwise you wouldn't be here talking today so you kind of want to carry on some of that tradition, as well" (27010).

The theme of intergenerational farm continuation of pulling the past forward in time was directly described by many farmers throughout the region. A farmer in Michigan said, "In all honesty and morality, we need to be careful and preserve it for next generations and leave our legacy behind" (26027). "Long-term sustainability," another Michigan farmer remarked, "is maintaining the farm and trying to improve the farm so that generations that come after me still have something to work with" (26004). An Ohio farmer declared, "The farm gets passed down from generation to generation in as good or better condition than you receive it" (39012). "I guess sustainability means that I'm doing things in a way that keeps my factor efficient and productive and gives me the ability to continue doing what I do," says a Minnesota farmer, "continue doing what *we* do, hopefully, for the next generation, generation after that" (27021).

Some farmers suggest they perceive the sustainability of their decisions to resonate through long-term time frames that may be more congruent with climate timescales. For instance, one Michigan farmer remarked, "We got to think down the road more than my lifetime to make sure the environment's going to be—or have the ability—to grow crops and keep the next generation going" (26005). The farmer concludes this thought with, "I mean, long term's not a year—it's not my lifetime." One Missouri farmer provided a similar thought: "I guess the long-term goal is sustainability and how can we improve the tilth of the soils and the environment, and the livestock operation, to where it has the long-term benefits not only for this generation but generations to follow" (29037). Livestock production is often a multi-year operation and may allow farmer to consider agricultural decisions beyond annual timescales.

Discussion

The concept of sustainability in agriculture is grounded in time with past actions influencing current conditions and future possibilities. Farmers in our sample viewed sustainability as bringing the past forward into the future. The data provide evidence that sustainability, climate, and agricultural risks are assessed through a lens of affective response formed by past personal experiences and historical intergenerational narratives. These experiences and historical events construct local knowledge and build social learning. This knowledge acts as a filter through which scientific experimental/objective knowledge is perceived and evaluated for its usefulness and usability in agricultural decision-making.

These farmer interviews offer strong support that the past is intimately connected to the present and future and often used to guide current decisions about the farm enterprise. Further, farmers do seem to delineate the recent past from the historical past, suggesting that the temporal reference model provides a good starting framework from which to identity key variables that represent the past. The iterative nature of incorporating past events, past decisions and resulting outcomes as information for a "now" decision is particularly apparent in farmer discussions about sustainability and long-term goals for their farms. What is not clear from these interviews is how recent past and historical narratives differentially influence current decisions. Future research might consider the differential impacts of transformative events (such as extreme weather) or incremental events (such as gradual changes in climate over time). For instance, does the past experience have to be a huge event, a disaster, or remarkable success to be recalled and given substantial weight to be incorporated into the decision? Further, how might patterns of the past be utilized to improve adaptive management responses to a changing and highly variable climate?

Jackson et al. (2010:80) suggest that "maintenance of future options requires preparation for uncertainty, and for quick and agile adaptation, given the rapid pace of change… This is in contrast," they continue, "to simply sustaining the present conditions." Our data suggest that Midwestern corn farmers largely perceive adaptation to climate risks for agricultural sustainability as bringing the past forward. This may inhibit "quick and agile adaptation" and disrupt the adaptive flexibility required to maintain resilient systems facing uncertain future climate risks. It is necessary, therefore, to consider how current management decisions are iteratively always moving to being the "past" and informing future "nows." This suggests that the past not only informs the current here and now, but influences the pathways of future decisions and outcomes. Giving preference to past experiences may privilege "path dependence" along the current trajectory and limit adaptive capacity for response to future uncertainty and change (Inwood et al., 2013:363). Better understanding of how individuals privilege past experiences and historical narratives can help us reorient our interventions and personal awareness and improve how agricultural climate risks are addressed.

Many conservation practices, such as reduced tillage and cover cropping, produce agronomic and environmental benefits that are compounding over time (Lal, 1993, 2002; Grandy et al., 2006). In other words, benefits of these management practices may not be realized within annual time cycles; rather, benefits accrue in longer-term time horizons. As a result, it may be challenging for a farmer or land manager to balance risks and benefits of farm enterprise economics, soil health, and carbon sequestration or increases in soil organic carbon.

Regional case studies that document peer farmer success over time may be helpful in communicating effects which are compounding over time. These case studies should include both current and past yield data, changes in soil organic carbon loss/gain, and water monitoring for nitrogen and phosphorous levels over time so that farmers can directly compare and create their own analogs from their personal past experience. Performance-based management processes track these kind of data and use past management and outcomes as benchmarks from which to make future management decisions (Morton, 2008). By viewing soil data in relation to other fields within the watershed, for example, farmers may be more inclined to shift their soil management techniques. Measuring, monitoring, and evaluation of past field, farm, and watershed level activities by farmers involved in performance-based management watershed groups have been shown to change beliefs and knowledge of farmers as well as their practices (Morton, 2008).

During the historical drought year of 2012 in the Midwest corn-belt, many no-till corn crops produced greater yield than crops in a continuous tillage system (Kumar et al., 2014). Viewing the agronomic data of peer farmers using conservation management techniques may allow farmers to develop analogous cognitive representations of their own management decisions in relation to their personally experienced climate risks, environmental conditions, and agronomic outcomes. By making comparisons to other regionally-relevant operations, farmers may better understand how certain management techniques, such as no-till, have performed over time and in different weather and climate conditions.

Conclusion

Agriculture is a complex human-natural system with intricate and continuous feedback loops. Like all humans, farmers learn from the past. Intergenerational narratives and experiences with recent past extreme weather events and variable climate patterns often become analog years used as benchmarks to build knowledge of the natural environment and guide decisions. This social learning process combines synthesized knowledge from the past, values, and new factual information that impacts outcomes for the farm enterprise and the dynamic relationship it has with the agroecosystem. Famers have different histories and these histories uniquely inform the values, beliefs, risk perceptions, and confidence they bring to decisions large and small on their farming operation (Arbuckle et al., 2014). The challenge ahead is to help farmers successfully adapt to changing climate conditions and changes in the agroecosystem. Ensuring sustainability at the farm and landscape levels under a variable climate means accomplishing multiple objectives: livelihood, co-production of good yields and preservation of soil, water resources and other ecosystem services needed in the “now” and in the future.

Climatologists in the North Central Region are an important bridge between climate risk information and agricultural data users. Many climatologists have important insights and understand the challenges and barriers to effectively communicating climate risk (Wilke and Morton, 2015). The temporal reference concept has been articulated well by one climatologist who remarked that analog years were useful in talking with farmers: “… if a producer says, ‘You know, I really remember summer of 2005—it was really wet.’ I think what happened in the past and what that person did has a big influence. Kind of their own personal history with farming and what they remember the weather like” (703).

This suggests that highlighting personally experienced and regionally-relevant information can help influence perceptions of the usefulness and usability of available climate information. Matthews et al. (2016:37) explore how to bridge climate science with wider society and conclude that “framing future climate scenarios in the context of extremes from living memory will help communicate the scale of the challenge climate change presents.” Haigh et al. (2015) similarly suggest that historical climate information may assist in quantifying potential uncertain climate risks for agriculture stakeholders. The climatologist above continued to expand on the use of historical analogs which resonate with farmer memories:

> “I think as climatologists our knowledge of possibilities in the future and uncertainties and helping to identify risk—that’s probably a good use of our knowledge. Maybe even using analog years. Say in the future it might be more like the heat and dryness of the 1930s, for example. Maybe not that extreme, but trying to find ways to use, say, the historical climate or things that people can remember or put into context as a guide for the future. I think that’s one way that we can help” (703).

Qualitative analysis of farmer interviews provides preliminary support for the temporal reference framework. However, limitations in the generalizability of this sample suggest more empirical testing is necessary to further validate the model. Interviews should be conducted with other agricultural stakeholders—including certified crop advisors, input dealers, agricultural scientists, and extensions educators—to assess their perspectives of time in relation to climate and agriculture. Further, survey questions should be developed and validated to quantify the time range of historical influence for decisions relevant to climate and agriculture. This will allow scientists to further parse out the specific time frames and contributions of recent past experiences and historical narratives. Content analysis of historical documents can also provide insight into how transformative extreme weather events, such as drought and floods, impact regional changes in agricultural management techniques.

These findings have practical application for climate and agronomic scientists and other stakeholders who bridge climate science information and agricultural decision-making. A recent U2U-CSCAP report, “Climate Change and Agricultural Extension: Building capacity for land grant extension services to address the agricultural impacts of climate change and the adaptive management needs of agricultural stakeholders,” suggests the need to “Talk about trends over time” (Morton et al., 2015). By doing so, climate risk communication efforts should not only rely on future-oriented or foresighted strategies, but rather incorporate a time range that includes temporal reference to historical events and past experiences. This may allow farmers to accept and utilize information about the compounding effects of soil management decisions over time, for example, to develop effective climate risk management strategies that ensure productivity and resilience of agricultural landscapes well into the future. By connecting climate science to agricultural traditions, we may better manage landscapes of the future.

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CHAPTER 4.

INFLUENCE OF SOCIAL PRESSURES ON THE USE OF SOIL CONSERVATION PRACTICES

A paper to be submitted to *Society and Natural Resources*

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Abstract

Social and ecological concerns are growing around issues of soil erosion and climate change risks to agricultural production. Soil conservation practices, such as conservation tillage, no-tillage, and cover cropping are consistently recommended as practices to benefit soil health and ensure long-term crop productivity. However, adoption of these techniques has not consistently spread across the upper Midwest landscape. Previous research suggests that family values and social norms can influence decisions about agricultural practices and strategies. There remains a gap in understanding to what extent do previous generations and social norms influence soil conservation practices. Further, it is unclear whether influence of prior generations of family promote or inhibit the adoption of science-based climate adaptation strategies that affect agricultural soil resources. The temporal reference framework posits that individual social learning processes incorporate past events, experiences and family and social norms and are often used to guide farm management decisions. This paper analyzes a 2015 survey of 1,159 Iowa farmers and 20 in-depth interviews with Iowa farmers to explore the role of family intergenerational influence in soil conservation decisions. A binary logistic regression is used to test the roles of family and social pressures in soil management practices. Results indicate that social learning influences how farmers reference their decisions to use fall tillage and cover crops. This suggests that soil management, such as post-harvest tillage, may not stem from agronomic rationale alone; rather, social and cultural norms provide context to justify (or not) the use of certain practices. Future research should incorporate larger spatial analysis to determine when and how social norms are influenced by geographic location, topography, and land-use histories.

Introduction

The practice of soil management is an important issue for the future of agriculture and society as concerns emerge at the intersection of food security, environmental quality, and climate uncertainty. Farmers and land managers are tasked with utilizing currently available agronomic and climate science data to guide best management options that ensure productivity and ecosystem services from soil resources into the future. Conservation tillage, no-tillage, and cover cropping are consistently recommended as techniques to reduce erosion and benefit soil and water quality (Delgado et al. 2011; Iowa Nutrient Reduction Strategy 2013; Walthall et al. 2012). However, use of no-till accounts for less than 25% of farmland in the state of Iowa and cover crops are planted on around 2.6% of farmland acreage nationwide (NASS 2014). Previous findings indicate an influence of social norms and cultural traditions on soil management (Wilson 2001; Carolan 2005; 2006) and suggest need for further exploration of how social factors impact adoption of soil conservation strategies.

Decisions about agricultural soil management are informed by individual knowledge and both ecological and social feedbacks which promote learning and influence decisions (Nowak 1992). This knowledge is developed through multiple channels, including (1) personal observation and experience of natural conditions, such as soil type or field slope, (2) scientific experiments conducted on analogous situations or locations, such as similar cropping system in nearby location, and (3) social learning that filters information through culturally-referenced values and beliefs (Morton et al. 2015; Kahan et al. 2011). The temporal reference framework proposes that past personal experiences and intergenerational narratives reinforced through family and community networks may act as reference points which are brought forward to inform current and future decisions (Wilke and Morton, 2016). It has been well documented that family values influence farm management practices in upper Midwest agricultural systems (Salamon, 1992; 1993) and previous research suggests that households are an important unit of analysis to understand agricultural decision-making (Lobao & Meyer, 2001). However, there is still a lack of clear explanatory variables to more completely understand the social influences impacting agricultural best management practice adoption, specifically soil conservation techniques (Prokopy et al. 2008).

This paper begins by presenting the temporal reference framework and the social learning processes by which family and social norms are integrated into individual knowledge. Then, literature on family social norms and pressure and family intergenerational influences in agricultural decision-making are reviewed. Both time and spatial scales are thought to be incorporated into social and ecological learning which form the knowledge base that guides decision-making. This study examines Iowa farmers' perspectives using survey and interview responses to quantify and describe the role of social influence—such as family pressures and neighborhood expectations—on decisions whether to utilize three in-field practices for soil conservation. Decisions to increase, decrease, or maintain current use of (1) fall tillage, (2) no-till, and (3) cover cropping are used to explore and test this theory. Random sample survey data of 1,159 Iowa farmers from the 2015 Iowa Farm and Rural Life Poll and 20 Iowa farmer in-person interviews conducted in 2013 provide data on farmers' social relationships and soil management decisions. Binary logistic regression is used to test hypotheses associated with fall tillage, no-till, and cover cropping. Results from logistic regression models are presented and elaborated using data from the qualitative interviews. A discussion of findings is followed by concluding observations and applications.

Temporal Reference Framework

The temporal reference framework posits that human orientations to time—including reference to past experience and historical narratives—guide farmer decision-making and normative behaviors (Figure 3.2) (Wilke and Morton, 2016). In particular, personally experienced past events and historical intergenerational narratives are used to create new individual knowledge through social learning processes and become information sources used in making current decisions. Temporal reference is a "stable, trait-like characteristic" in predicting climate change-relevant decisions, and has been a consistent predictor of environmental behaviors (Dietz et al. 2007:192; Milfront et al. 2006, 2012).

Social learning is the mechanism whereby humans develop knowledge through the process of observing others over time (Bandura 1977). The process of social learning inherently involves a scale of time because the necessary components—observing behaviors, remembering behaviors, and replicating behaviors—generally occur in sequential order (Bandura 1977). Of course, not all learned behaviors are remembered and replicated. For example, some learned behaviors may be adjusted to conform with changes over time in dominant social norms. Also, other sources of knowledge—such as institutional knowledge—interact with socially learned forms of knowledge to ultimately guide motivations and direct behavioral actions and intentions (Schusler et al. 2003). The role of proximate and socially-referenced groups of influence, most often comprised of family members, also provide a large component of the social learning process (Salamon 1992; Salamon et al. 1997).

Social learning processes occur throughout the temporal reference model as past decisions and their outcomes are selectively brought forward to inform current decisions (Figure 4.1). The iterative nature of social learning suggests that humans reference multiple timescales as they consider decisions. As a farmer considers the decision to perform fall soil tillage, for example, he may assess that decision in reference to some past experience and perceived benefits of black soil exposed to facilitate warming up or drying out soil to hasten spring planting. This reference for guiding decisions does not result completely from individual knowledge; rather, past experience of fall tillage—both individually observed and shared through family narratives—provide foundation to inform decisions. In this case, an action occurring at decision point (DP) 3 is referenced relative to multiple previous outcomes (Outcome 2 and Outcome 1). In other words, a farmer may perform the action of fall tillage as they reference and weight the tillage practices conducted by their father and grandfather.

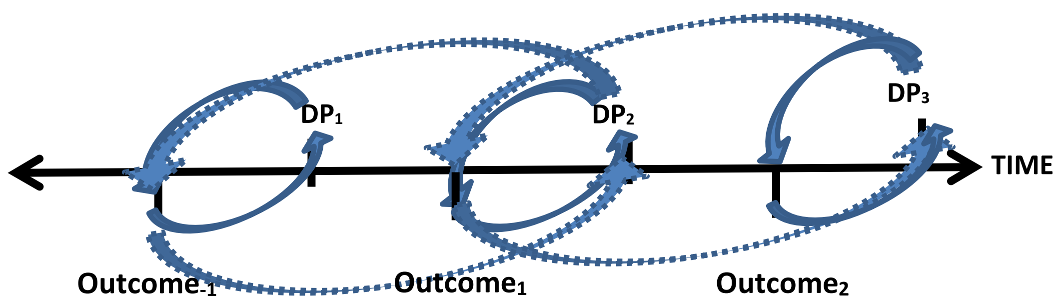

Figure 4.1. *Temporal Reference Model. Outcomes are given different weights based on perceptions and meanings assigned to the past and their impacts. In this model, decision-makers reference back to multiple timescales and outcomes.*

Social Learning

Normative behavior is reinforced or adjusted over time through knowledge development that results in part through social learning (Nerbonne and Lentz 2003). According to Nerbonne and Lentz (2003), social learning occurs during the integration of various knowledge systems which provide a foundation for collective experience. This collective experience is then translated and reinforced through narratives, or collective representations of cultural phenomenon. Social knowledge develops as various knowledge systems—including both ecological and social systems—interact with one another and the real world. Narratives of collective experience are brought forward through time via accounts and stories of transformative events and experiences (Wilke and Morton, 2016). As Lind-Riehl et al. (2015:96) articulate, “Social influence occurs when behavioral expectations emerge and take hold within a community over time.”

The narratives which contribute to social learning may result from a hierarchy of ecological and social sources (Folke 2006; Collins et al. 2001). Building upon the coupled ecological-human systems literature, Figure 4.2 presents an adaption of six distinct levels of information and knowledge that can be sources of actionable knowledge. The arrow in the figure represents dynamic and iterative incorporation of knowledge from both sets of circles. Actionable knowledge may be thought of as the knowledge which immediately precedes a decision. The actionable knowledge multi-directional arrows correspond to the curved blue lines in figure 4.1 which carry forward past outcomes and decisions to the current decision point. Similar to the concept of grounded knowledge, actionable knowledge forms as ecological influences are linked geographically while social influences are situated within self-identified social references (Ashwood et al. 2014). For example, “institutional knowledge,” or federal and state level policy, interact and influence (positively or negatively) family and neighbor knowledge and norms. This mid-level knowledge system subsequently influences individual knowledge; when the three levels of knowledge combine, they provide the platform for an individual to develop actionable knowledge and basis for executing a decision. Given the prominent role of family influence on agricultural decision-making documented in the literature (Salamon 1992; McMillan 2015), along with the current gap in understanding to what extent family and neighbor norms influence soil conservation, this study will focus on 1) social norms and pressure and 2) intergenerational narratives to assess family-level social pressures influencing a farmer's decision to increase, decrease, or remain consistent with current use of fall tillage, no-tillage, and cover cropping.

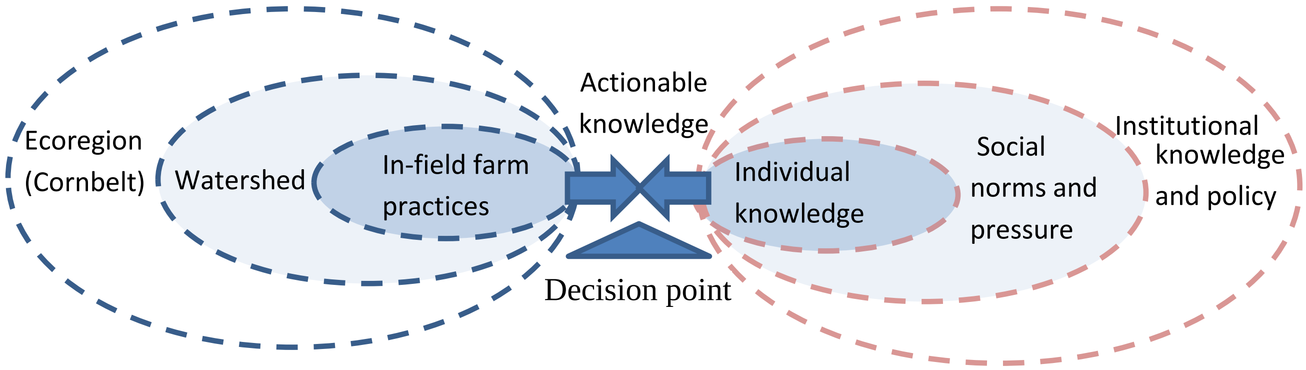

Figure 4.2.. Actionable knowledge development. Actionable knowledge development and understanding stems from a nested hierarchy of ecological and social systems (Adapted from Folke (2006)). Dotted red lines depict the permeable boundaries that convey information over time through the mechanisms of social learning. Individual knowledge refers to individual-level beliefs and values concerning land stewardship ethic. The level of family/neighbor knowledge and norms refers to social pressures and intergenerational family influence.

Family Social Norms and Pressure

Social and cultural norms are important influences that may confine or restrict an individual's range of possible actions. According to Coleman (1990:243), "a norm concerning a specific action exists when the socially defined right to control the action is held not by the actor but by others." In the case of farm family decision-making, the "right to control the action" can be held by other family members, commonly an elder patriarch (father or grandfather). These norms may often be subtle and unspoken and manifest over time as symbolic narratives. Symbolic narratives are stories about events and experiences that reinforce social norms (Loseke 2007). Narratives are influential in how humans make sense of their lives and make decisions, and are most often referenced in relation to others in close proximity (geographic and social proximity) to them, including family (Fivush 2008). In this case, intergenerational narratives—stories about events and experiences that have relevance to ancestral and descendent family members—may reinforce or refute dominant cultural norms (McMillan 2015; Salamon, et al.

1986; 1997). Intergenerational narratives are considered to impact agronomic, conservation, and culturally-normative decisions.

Cultural norms may broadly be considered as the standards by which we live and behave. According to Neuman (2009:15), cultural norms are “shared expectations and rules that guide behavior of people” and “are learned and reinforced from parents, friends, teachers and others while growing up in a society.” There are risks and benefits involved with accepting and adhering to normative behaviors. Individuals who do not follow norms “may be shunned or suffer some kind of consequence (Neuman 2009:15). Normative behavior has and can change over time; however philosophers and other scientists have grappled for centuries about how and why norms are modified or changed. In this research, the intent is a better understanding of the impact of family and cultural norms on a farmer’s decision about soil conservation.

Family Intergenerational Influence

Several lines of research have highlighted the role of family values and expectations in providing a blueprint or guide to which farmers reference agricultural decisions (Salamon 1992; McMillan 2015). One of the most prominent examples results from anthropological studies of German and Yankee communities in central Illinois in the 1980’s and illustrates how intergenerational family values passed forward through time reinforce traditionally held notions of family heritage (Salamon 1992). For example, Salamon (1993) documented that predominantly German-originating families made risk-averse choices, held on to inherited land, and managed succession to assure continuity. On the other hand, Yankee-originating families made choices for business advancement, economics, and willingly negotiated farm succession and sold inherited land. By analyzing plat-map records, Salamon (1992;1993) found that during the 1980’s, German-originated family ownership doubled and average farm size decreased, while Yankee-originated family ownership and farm size remained relatively stable. This occurred, according to Salamon (1993:588), because “German landowners were more persistent in holding land than Yankee landowners,” leading to an increase in land tenure.

Salamon’s (1992) original work has since been replicated and tested in recent years. For example, McMillan (2015) conducted in-depth interviews with 20 farm families in southern Wisconsin. Selected participants were third-generation farmers who self-reported family origins dating back from northern Europe in what is now Germany. McMillan (2015) reported similar findings highlighting the importance of land tenure and family farm succession. Findings also suggest the prominence of gendered decisions dominated by patriarchal objectives of maintaining the family name. McMillan (2015:56) concludes, similarly to Salamon (1992;1993), that German heritage farmers foremost "prioritize and fulfill the yeoman goal of keeping the farm in the family name." This is interpreted as illustrating a continuous dialogue and balance between "historically persistent cultural tradition" and pressures of modern agricultural production.

The influence of shared family values and norms extends beyond land tenure and influences adoption of sustainable practices (Salamon et al. 1997). A more recent study of farmland conversion to bio-energy tree crops in Alberta, Canada parallels results from the Midwest region. Neumann et al. (2007) found that economic incentives alone will not influence willingness to adopt non-traditional land uses (such as tree crops). Rather, family factors—including number of children and percent of family income from farming—had significant direct effect on willingness to consider non-traditional land uses (Neumann et al. 2007). Interestingly, individuals with stronger family-orientation were less likely to consider land use changes. Neumann et al. (2007:114) suggest that "when a farmer is connected with the previous generation, his or her way of doing things is anchored in established, traditional methods, and thereby limited in the potential for innovation." However, Abd-Ella et al. (1981) found the opposite: farmers with stronger family goals were more likely to try innovative farm management techniques. It is clear that family influences farm decision-making, although questions remain to what extend family influence increases or decreases willingness to adopt conservation management practices.

The influence of family values on farming decision-making is often unspoken, invisible, and challenging to understand. As Salamon (1993:582) notes, "the shared set of beliefs constitutes a schema that serves as an interpretive framework and a scenario for decision-making actions…Such practices typically are taken for granted and carried out without thinking." How family values reinforce or challenge existing social and cultural norms are thought to influence management decisions. The temporal reference framework (Figure 4.1) posits that social learning is the mechanism by which social norms become synthesized and perpetuated through family structures over time. Individual learning and knowledge development occurs when the decision maker reaches back to pull forward historical family norms and values and uses this information to guide the decision at hand. The process of social learning is thus paramount to the development of individual stewardship ethics reinforced by social pressures over time.

Study Context and Research Question

The United States Corn Belt Region encompasses an area east from Nebraska to Ohio and south from Minnesota to Missouri, with production roughly centered in the state of Iowa. Beginning post-World War II and escalating during the 1980's farm crisis, adjustments from multi-year rotational grain-cropping systems to systems which continuously grow corn or a rotation of corn-soybeans have increased soil erosion and the flow of excess nutrients from farm fields to waterways (Hatfield et al. 2009). Risks associated with soil loss and nutrient leakage have resulted in research and attention directed toward in-field soil conservation practices (Walthall et al. 2012; Iowa Nutrient Reduction Strategy 2013). Three in-field management practices that affect the soil resource across the Corn Belt Region are timing of tillage (fall or spring); no-till; and cover crops. According to the scientific literatures upon which the Iowa Nutrient Reduction Strategy (2013) is based, conservation tillage (chisel compared to moldboard plowing) reduces phosphorus loading by an average of 33%, while no-tillage (compared to chisel plowing) reduces phosphorus loading by an average of 90%. Cover crops reduce nitrate-nitrogen concentrations by an average of 31% (cereal rye) and 28% (oats), depending on cover crop species.

In the state of Iowa, over 90% of the farmland acreage is utilized for the production of corn or soybeans (NASS 2015). Iowa is an important producer of global grain supply and a leader in developing science-based conservation strategies (Iowa Nutrient Reduction Strategy 2013; NASS 2015). However, in-field soil conservation recommendations outlined in the nutrient reduction strategy, such as reduced tillage, have not yet been adopted by a majority of farmers on the Iowa landscape. This study seeks to address the research question: To what extent do previous generations and social norms influence soil conservation practices?

Three specific practices serve as dependent variables: Fall tillage, no tillage, and cover cropping. No tillage and cover cropping are regarded as soil conservation practices because they are indicated by scientific literatures to be effective in-field practices to reduce soil erosion and off-field phosphorous and nitrate-nitrogen leakages (Al-Kaisi et al. 2005; Al-Kaisi & Yin 2005;

Deen & Kataki 2003; Lal 1993; Tonito et al. 2006). Fall tillage is regarded as a “traditional” soil management practice because use of fall tillage is embedded in historical narratives of how agriculture has been performed on the tallgrass prairie landscape since the arrival of European-origin settlers in the late 1800’s (Lal 2009). Agronomic scientists at agricultural land-grant institutions have recommended against the practice of fall tillage in most management operations and regions in Iowa (Iowa State University 2014).

Individual farmer management decisions are proposed to be influenced by family intergenerational influence and social pressures, which contribute to social learning processes described in the temporal reference framework. It is expected that family intergenerational influence and social pressures will significantly affect farmer reported increase in two soil conservation practices (no tillage and cover cropping) and decrease in one traditional soil management practice (fall tillage) relative to no change in these practices. Expected relationships are described as follows:

H1: The influence of previous generations will affect the decision to increase or decrease soil management practices relative to no change, specifically:

> H1a: Increased influence of previous generations will be associated with no change in the use of fall tillage.
>
> H1b: Increased influence of previous generations will be associated with no change in no-tillage.
>
> H1c: Increased influence of previous generations will be associated with no change in use of cover crops.

H2: It is expected that the influence of social pressures will affect the decision to increase or decrease soil management practices relative to no change, specifically:

> H2a: Increased influence of social pressures will be associated with no change in the use of fall tillage.
>
> H2b: Increased influence of social pressures will be associated with no change in the use of no tillage.
>
> H2c: Increased influence of social pressures will be associated with no change in the use of cover crops.

Methods

Survey and interview data

A mixed-methods approach is employed utilizing random sample survey data from the 2015 Iowa Farm and Rural Life Poll and 20 Iowa farmer in-person interviews conducted in 2013. In this study, the mixed-methods approach provides qualitative data to complement and enrich quantitative model interpretation by providing quotations that help assure transparency and ground-truth results (Prokopy 2011). Quantitative data gathered through survey responses allow efficient and larger sample sizes of information for analysis and modeling and generalizing to the larger population of Iowa farmers (Dillman et al. 2009; Neuman 1994). Qualitative interview data assists model interpretation by providing further explanation of results with in-depth and contextualized information (Neuman 1994; Prokopy 2011).

The Iowa Farm and Rural Life Poll is an annual panel survey of Iowa farmers conducted by Iowa State University Extension in partnership with the Iowa Department of Land Stewardship and the USDA National Agricultural Statistics Service. The questionnaires were mailed to 2,093 Iowa farmers in February 2015 and 1,159 surveys were received for a response rate of 55 percent. Participants are 65 years old, on average, and farm an average of 441 acres. This sample of farmers is slightly older than the general Iowa farmer population and farm more acres on average, according to the 2012 Census of Agriculture. For more detailed survey methodology, see Arbuckle (2016).

Qualitative data were obtained from a larger sample of semi-structured in-depth interviews with 159 predominantly corn-soybean crop farmers in the Corn Belt (see APPENDIX A). These interviews were conducted as part of a nine state collaborative effort to better understand farmers' perceptions about climate impacts to agriculture, use and perceived barriers to conservation practices, and sources of information (see Roesch-McNally 2016). In-person interviews were conducted by Extension educators and social scientist in the spring and summer of 2013 in Illinois (9), South Dakota (14), Missouri (16), Ohio (18), Indiana (20), Iowa (20), Minnesota (20), Michigan (20), and Wisconsin (22). This study was approved by Iowa State University Institutional Review Board (IRB) #12-473.

Purposeful sampling of farmers connected to Extension networks resulted in a sample that may be considered more conservation-oriented. In other words, these farmers are more likely to have tried soil conservation practices, such as no-tillage and cover cropping. This sample was selected to gain more information about challenges and benefits associated with conservation practice adoptions. Qualitative interviews were transcribed and analyzed using NVivo 10 (Nvivo 2014). Twenty interviews were selected from the larger regional sample to represent all interviews conducted in Iowa.

Iowa farmers (N=20) were directly asked about their use of tillage and cover crops, and where they get information about tillage and cover crops. Questions about (1) use of tillage and cover crops, (2) sources of information about tillage and cover crops, and (3) perceived barriers to use of reduced tillage and cover crops are examined. Key themes of interest to this research include references to family and neighbor influence, social norms and pressures, and social sources of information or knowledge development. Examples of these themes include such topics as concern for visual appearance of farm, interactions with family about farming decisions, and exchanges of information in social settings, such as community events or coffee shops.

Variables in the model

Three dependent variables representing soil management practices are used to help determine the extent to which previous generations and social norms influence management decision-making. "Soil conservation practice" refers to conservation tillage (defined as minimal tillage or no-fall tillage which leaves >30% residue for spring planting), no-tillage (defined as not plowing and leaving most crop residue, including grazing grain stubble), and cover cropping (defined as planting a crop for growth during fall, winter, and spring season in between "cash crops"; also includes grazing) (Mannering & Fenster 1983; Hanna 1990; Derpsch 2003). These three practices were selected from a list of responses to the following question prompt about changes in farming practices and strategies: "As conditions and technologies change over time, farmers can adapt by making changes to their operations. Thinking about the last 10 years or so, how has your use of the following practices changed in the farm operation?" Respondents were instructed to circle one response of six provided: (1) Not applicable, (2) Major decrease, (3) Moderate decrease, (4) No change, (5) Moderate increase, and (6) Major increase. These responses were combined into three categories: Decrease (major and moderate decrease), No change, and Increase (moderate and major increase). The "Not applicable" response was dropped because it implies the practice is not applicable to the farmer's operation.

Independent variables were selected to measure latent theoretical concepts. First, review of literature indicates a prominent role of family intergenerational influence on farm decision-making (Abd-Ella et al. 1981; Salamon, et al. 1986; 1997; Neumann et al. 2007; McMillan 2015). The temporal reference framework posits that intergenerational narratives reinforce and bring forward historical social norms and behaviors (Wilke and Morton 2016). Through the process of social learning, these historical norms may influence an agricultural decision-maker and act as social pressures to reinforce family norm. In other words, family history may provide a blueprint for action and can influence "path dependence" to reinforce traditional decision processes that adhere to acceptable social norms (Inwood et al. 2013:363; McMillan 2015). Family intergenerational values and social pressures are distinct but connected concepts that are expected to influence soil management practices.

To develop indicators of these concepts, five summated scales were developed from two 2015 Iowa Farm and Rural Life Poll survey questions. Summated scales are considered superior measures compared to single-items or simple response categories because utilizing multiple single-item scales improves precision and reliability of measurement (DeVellis 2003; Arbuckle 2013). Five scales were constructed from farmer responses to two survey questions. The first three scales measure family intergenerational influence of on-farm management. They were derived from responses to the following question: "In general, how much influence do previous generation(s) of your family have on the way you currently manage the following aspects of your farm operation?" Survey respondents were instructed to circle one response for each item (Not applicable, No influence, Some influence, Strong influence, Very Strong influence).

The fourth and fifth scales measure factors influencing decisions about soil and water conservation. These scales derived from responses to the question: "The following are some factors related to decisions about soil and water conservation. Thinking in general about the conservation practices that you have used in your farm operation over the years, please rate how important the following factors have been in decisions to incorporate conservation practices into your operation." Respondents were instructed to circle one response for each item (Not at all important, Slightly important, Moderately important, Important, Very important). The "Not applicable" response category was dropped from both questions. Variables are treated as continuous (Q#11: No influence =0, Very Strong = 3) (Q#14: Not important = 0, Very important = 4).

Three scales measure conceptual dimensions of Family Intergenerational Influence (Agronomic, Conservation, Cultural) obtained from responses to Q#11. The three scales may be considered as three distinct factors: (1) Agronomic decisions, (2) Conservation approaches, and (3) Cultural symbols (Table 4.3). Agronomic decisions often occur upon an annual time scale. Some decisions, such as crop rotations, would occur once per calendar year. Other decisions, such as pest management, may occur multiple times per year depending upon crop, field and weather conditions, and management system. Conservation approaches generally represent in-field management decisions that extend beyond one year and encompass multiple years. Subsurface tile drainage has historically been considered a conservation practice in the Prairie pothole Region of Iowa (Kanwar et al. 1988). Cultural symbols are components of agricultural management which resonate externally to peers and others within a farmer's social circle. In other words, they represent certain farming practices or decision which can become viewed as cultural symbols (such as loyalty to "green" (John Deere) or "red" (International Harvester) tractors). Three distinct sub factors representing various component of intergenerational family influence are helpful to more specifically understand family influence on farm management.

Two measures of the representative concept, Social Norms and Pressure, are obtained from responses to Q#14 (Table 4.4). Stewardship ethics are internal motivations often decided at an individual level. Social pressure results from the influence of social and cultural norms that impact a decision. These scales parallel the hierarchical stages of knowledge influence presented in Figure 3.1: "Individual Knowledge" corresponds to individual stewardship ethics, while "Social norms and knowledge" corresponds to social pressures. Social pressures result as family intergenerational influence is transferred through social learning to confine, approve, or disapprove certain behaviors and actions (Bandura 1977). As social learning occurs through time, the role of family influence shapes normative behaviors (Salamon 1992) and has potential to flow through the permeable boundary between social and family influence and contribute to individual-level decision-making (Nerbonne and Lentz 2003).

Three control variables, age, education, and gross farm revenue, are included in the model because they have consistently shown to influence best management practice adoption among the farming population. The influence of age on conservation behavior has been shown to depend on the type of practice (Knowler and Bradshaw 2007), although Baumgart-Getz et al. (2012) found older farmers as less likely to adopt conservation. Education has been demonstrated to influence conservation adoption. However, a synthesis of the literature found education to both positively and negatively correlate with conservation adoption (Knowler and Bradshaw 2007). Revenue, measured in gross farm sales, has been demonstrated to positively predict conservation practice adoption (Baumgart-Getz et al. 2012). Control variables were obtained from Q#18 (What age are you? Open ended), Q#20 (What is your highest level of education you have completed? Less than high school, High school graduate, Some college, Bachelor's degree, Some graduate school, Graduate or professional degree), and Q#24 (Which category best represents your gross farm sales for 2014?).

Analytical Approach

Data analysis occurred in two stages. The first used binary logistic regression to model relationships between 3 dependent and 8 covariate variables. Dependent variables were transformed to three ordinal categories: (1) increase, (2) no change, and (3) decrease. Following agronomic recommendations in the literature, the following adjustment were made to the dependent variables: Fall tillage increase (13.6%), No-tillage decrease (5.5%), and cover crop decrease (4.2%) were dropped from the analysis. This allows for clearer examination of the conceptual categories of interest: decrease in fall tillage, and increase in no-tillage and cover crops. The binary logistic regression thus compares no change to reported change for fall tillage (0=no change, 1=decrease), no-tillage (0=no change, 1=increase), and cover crops (0=no change, 1=increase).

Results

Dependent variable means and percentage distributions (Table 4.1) illustrate that some farmers report increasing soil conservation practices, including no-till (43.9%) and cover cropping (35.1%), while 34.7% report decreasing fall tillage. Over half of respondents indicated they have not changed fall tillage (51.7%), no-till (50.5%), and cover cropping (60.6%). Descriptive statistics for the five summated scales are presented in Table 4.2. Four of the five scales had a Cronbach's alpha reliability coefficient higher than .80, indicated high levels of internal consistency within the scales (Field 2009) (Table 4.2).

Table 4.1. Means and percentage distributions for dependent variables

Variable	N (Missing)[1]	Mean (SD) (1=decrease)	Decrease (%)	No Change (%)	Increase (%)
Fall Tillage	965 (194)	1.79 (.662)	34.7	51.7	13.6
No-Tillage	847 (312)	2.38 (.590)	5.5	50.5	43.9
Cover Crops	780 (379)	2.31 (.546)	4.2	60.6	35.1

1. Reported missing is combination of Not Applicable and system missing value. Not applicable = Fall Tillage (158), No-Tillage (268), Cover Crops (339).

It is helpful to put these means into context for comparison. According to the 2012 Census of Agriculture, no-tillage is practiced on around 25% of the corn-soybean acreage in Iowa (NASS 2014). According to the Census, 379,614 acres were planting into cover crops in Iowa, accounting for roughly 1.2% of the 30,500,000 acres of farmland (NASS 2014). This is less than the 2.6% of cover crops estimated on farmland nationwide. Use of cover crops has been more widely adopted in eastern regions of the Corn Belt (such as Ohio and Indiana), potentially because of longer growing season and larger amounts precipitation. There are no data available on the use of fall tillage practices because they are not reported by farmers; however, emerging technologies including Geographic Information System (GIS) may allow better monitoring of seasonal soil management practices in the near future.

Table 4.2. Descriptive statistics of five scales.

Factor	**N**	**Items**	**Mean (SD)**	**Range**	**Chronbach's Alpha (α)**
Agronomic	1101	6	1.739(.654)	1-4	.882
Conservation	1099	7	1.883(.6658)	1-4	.879
Cultural	1109	3	2.036(.722)	1-4	.686
Stewardship	1075	10	3.799(.773)	1-5	.835
Social Pressure	1084	3	2.543(.972)	1-5	.835

Factor loadings of the three Family Intergenerational Influence scales are listed in Table 4.3. The Agronomic scale is comprised of items that represent decisions related directly to crop production, such as fertilizer, tillage, and pest management. Items within the Conservation scale represent land stewardship-oriented decisions, such as soil and water conservation, wildlife habitat, and diversification. Tile drainage has historically been considered a conservation practice and is thus included within this factor (Kanwar et al. 1988). Sub-surface tile drainage may also be perceived as an adaptation strategy because climate science is indicating that farmers should expect more spring-time (April-June) precipitation, which shortens the planting window. The third scale, Cultural, represents external symbolic representations of farming decision, such as brand loyalty and farm appearance.

Table 4.3. Family Intergenerational Influence Scales. In general, how much influence do previous generation(s) of your family have on the way you currently manage the following aspects of your farm operation? (Please circle one on each line.) Principal Component Analysis Matrix. Varimax rotation, eigenvalue = 1.

	Family Intergenerational Influence		
	Agronomic	Conservation	Cultural
11a. My fertilizer program (type, timing, rates)	.790	.203	.180
11b. My pest management programs	.767	.221	.168
11i. The way I market crops and/or livestock	.749	.235	.177
11h. Decisions about what crop rotations to use	.643	.345	.302
11j. The tillage practices I tend to use	.615	.392	.239
11g. How I deal with extreme weather events	.525	.463	.276
11n. My land stewardship ethics	.120	.805	.309
11m. The kinds of conservation practices I use	.341	.772	.136
11k. How I manage wildlife habitat on my farm	.272	.716	-.007
11f. My approach to soil and water conservation	.256	.695	.353
11l. My perspectives on crop and livestock diversification strategies	.505	.587	.036
11p. My approach to tile drainage management	.349	.492	.381
11o. My beliefs about climate change	.426	.484	.092
11d. The brand(s) of tractor and equipment I tend to buy	.205	.104	.827
11e. The seed companies I trust	.487	.100	.617
11c. The way I keep up my farm's appearance	.099	.488	.582

Table 4.4 lists factor loadings of a set of two scales representing Social Norms and Pressure. The first scale, Stewardship Ethics, represents internal motivations and individual-level normative behaviors and pressures related to motivations for soil conservation. The second, Social Pressure, represents external social norms related to how proximate social groups (family and neighbors) and embarrassment of visual problems impact motivation for soil conservation.

Table 4.4. Social Norms and Pressure Scales. The following are factors representing social norms and pressures associated with decisions to practice soil and water conservation. Thinking in general about the conservation practices that you have used in your farm operation over the years, please rate how important the following factors have been in decisions to incorporate conservation practices into your operation (Please circle one on each line). Principal Component Analysis Matrix. Varimax rotation, eigenvalue = 1.

	Social Norms and Pressure	
	Stewardship Ethics	Social Pressure
14g. Protect the land for the next generation	.856	.078
14j. Because it is the right thing to do	.830	.083
14i. Protect my investment in the land	.815	.126
14q. Maintain or improve soil health	.806	.211
14l. Avoid polluting streams, rivers and lakes	.804	.185
14p. My stewardship ethics	.786	.145
14m. Maintain or enhance productivity	.734	.230
14s. Reduce the environmental impact of my farming activities	.653	.388
14u. Keep chemicals and nutrients on the farm	.606	.292
14h. Feeling of responsibility to earlier generations	.603	.333
14n. Improve wildlife habitat	.538	.314
14w. Neighborhood expectations	.099	.905
14v. Family member(s) encouraged me to	.129	.864
14r. Embarrassment about visible problems	.260	.742

Logistic Regression Results

Binary logistic regression was used to model decrease (fall tillage) and increase (no-tillage and cover crops) of three soil conservation practices. Results of the three models are presented in Table 4.5. The Nagelkerke pseudo R^2 is utilized in binary logistic regression similarly to r^2 in multiple linear regression (Tabachnick and Fidell 2007). Nagelkerke R^2 values of 0.105 (Model 1), 0.066 (Model 2), and 0.077 (Model 3) indicate adequate model fit. Hosmer and Lemshow test statistic values of 9.537 (p = .299) (Model 1), 3.292 (p = .915) (Model 2), and 6.411 (p = .601) (Model 3) indicate good model fit (Field 2009). Table 4.5 reports the logistic coefficient (B) and standard error (SE), and the exponentiated coefficients or log odds (Exp(B)).

Odds ratio values >1 indicate positive relationship, while odds ration values <1 indicate positive relationship (Field 2009).

Model 1: Fall tillage. Decrease in fall tillage is positively associated with Conservation scale of Intergeneration Family Influence ($p<.05$), Stewardship Ethic ($p<.05$), and revenue ($p<.05$). Fall tillage decrease is negatively associated with Social Pressure ($p<.01$). This suggests that farmers reporting decreasing the use of fall tillage in the last 10 years are significantly influenced by family intergeneration influence concerning conservation behaviors, individual stewardship ethics for soil and water conservation, and farm revenue. This follows previous literatures in that family-level conservation orientations permeate to individual-level conservation decision (McMillan 2015). Individual stewardship ethics similarly have been documented to influence conservation adoption (Knowler and Bradshaw 2007). Farm revenue is positively associated with decreased fall tillage, which follows previous literatures (Baumgart-Getz et al. 2012) and makes conceptual sense because increased tillage costs money (e.g. diesel) and labor. Social Pressures are shown to negatively influence decrease in fall tillage. This supports the expected relationship that increased influence of social pressures will be associated with no change in the use of fall tillage.

Model 2: No-tillage. Increase in no-tillage is positively associated with Stewardship Ethic ($p<.01$) and revenue ($p<.05$). This supports the expected relationship that greater influence of stewardship ethics will be associated with increased use of no-tillage. Similar to decrease in fall tillage, no-tillage is positively associated with increased farm revenue.

Model 3: Cover cropping. Increase in cover cropping is positively associated with Stewardship Ethic ($p<.001$). This supports the expected relationship that increased influence of stewardship ethics will be associated with increased use of cover crops. Increase in cover cropping is negatively ($p<.05$) associated with the Cultural scale of Intergeneration Family Influence. This suggests that individuals who are more influenced by cultural components of previous generations—such as farm appearance, brand of tractor, and trust in seed companies—are less likely to have increased the use of cover crops in the last ten years.

Table 4.5. Binary logistic regression results for three models (fall tillage, no tillage, cover crops). Each variables in the models includes Coefficient (standard error) and log odds (Exp(B)), Hosmer and Lemeshow values, and Nagelkerke's pseudo R^2.
* $p < .05$, ** $p < .01$ *** $p < .001$

Variables	**Fall tillage (Model 1)**	**Exp(B)**	**No-tillage (Model 2)**	**Exp(B)**	**Cover Crops (Model 3)**	**Exp(B)**
Constant	-.367 (.077)***	.693	-.116 (.077)	.890	.539 (.083)***	1.715
Agronomic	-.261 (.214)	.770	.039 (.211)	1.040	.226 (.223)	.798
Conservation	.456 (.213)*	1.578	.348 (.208)	1.417	.134 (.216)	.875
Cultural	-.092 (.152)	.912	-.189 (.150)	.828	-.324 (.165)*	1.382
Stewardship	.310 (.137)*	1.363	.383 (.137)**	1.466	.642 (.156)***	.526
Social Pressure	-.282 (.105)**	.754	.015 (.098)	1.015	-.068 (.103)	1.071
Age	.009 (.008)	1.009	.014 (.008)	1.014	.003 (.008)	1.003
Education	-.024 (.067)	.976	-.017 (.065)	.983	-.036 (.070)	.965
Revenue	.228 (.043)***	1.256	.079 (.038)*	1.082	-.063 (0.39)	.939
Hosmer and Lemeshow (*p* value)	9.537 (.299)		3.292 (.915)		6.411 (.601)	
Nagelkerke's pseudo R^2	.105		.066		.077	

Interview results

In-depth interviews of 20 Iowa farmers provide data to assist in the interpretation of the quantitative results and convey illustrative quotations to help assure transparency or analysis and ground-truth results (Prokopy 2011). Qualitative data analysis focuses on farmer response to question prompts concerning barrier and facilitators to the use of tillage (fall tillage and no tillage) and cover crops.

The entire farmer interview sample had heard of the three in-field soil management practices. The majority of farmers in the interview sample had tried or are currently doing no-tillage. Only a few farmers interviewed reported the use of fall tillage in select cases, such as to dry out flat bottom land fields in preparation for planting. About half of the interview sample reported trying or currently using cover crops. Several famers also illustrated a “wait and see” attitude for the adoption of cover crops, which is consistent with increasing uncertainty among upper Midwest farmers about adaptive management practice responses to climate risks (Morton et al. under review).

The role of local traditional social pressures in the decision to perform soil tillage is evident throughout the farmer interviews. One Iowa farmer described, “I feel that tillage is a very localized issue.” The farmer continued, “some of these old farmers around here have been farming it since they could reach the pedals on the old Allis Chalmers...when the old man had them get off the school bus and come out and moldboard plow it every year. ” This comment also evokes the role of past traditions and historical legacies of tillage. Another farmer references “these old farmers” as he discusses “these old guys that are 60 and 70 years old that used to moldboard [plow the soil] every year.” A third farmer elaborates on this topic and observes, “some of the older guys, they like to see that ground turned over, you know.” These quotes illustrate how tillage practices are brought forward through time in localized geographic proximity.

In responses to the question prompt, “Where do you get information about tillage?,” almost all famers described how tillage information is obtained through social networks. Farmers responded directly with answers such as: “Myself or from watching neighbors,” “Word of mouth,” “Mostly just talking with other neighbors,” “You talk to other farmers who have already done it,” “I want to see what's going on around me,” This finding parallels responses from the 2014 Iowa Farm and Rural Life Poll, in which more than half of farmers reported that they “do not use an adviser” when making decisions about tillage type (65%) and tillage timing (68.8%). Information about soil tillage systems appears to informally flow through proximate social networks and neighbors.

Farmers also elaborated about how they seek information from neighbors and other farmers in the area. For instance, one farmer suggested they learn “From fellow farmers...You try to watch the ones that you know are doing things right and, if it works for them, well, you know, you give a try.” Another farmer articulated the hesitance of waiting to ensure that no-tillage would be successful in their area: “Most of the information we get from other farmers who've already done it for years.” One farmer who had not yet tried no-tillage articulated hesitance, but consideration for future adoption, “I've heard from the neighbors are starting to think about doing it and I just haven't figured it out.”

Farmers also reported referencing other farmers’ experiences to consider and assess their own management decisions. For instance, one Iowa farmer remarked, “The guys who did a lot of tillage last year, really got hurt because they dried it out.” He continued by saying, “you'd think there'd by more people doing no-till.” Another farmer remarked, “Like this time of the year's a great learning time ‘cause you drive around and see what other people do and whether it works for them or not.” This illustrates how tillage management is a practice embedded in local geographic regions. One farmer observed: “I would go clear up into Minnesota where they were still moldboard plowing their corn stubble mainly to warm it up and because it was so flat and heavy and then it would mellow out nice in the spring after. But around here [Northeast Iowa], it seems like minimum tillage works good.”

Qualitative data also supported the positive relationship between farm revenue and decreased fall tillage and increased no-tillage. For example, on farmer remarked, “Tillage…destroys soil structure and it’s costly and time consuming.” The farmer concluded this thought by saying, “I don’t think there’s any benefit.” Farmers also mentioned the economic value of soil and how no-tillage and minimal tillage allow them to maintain, and even increase, this value. “We’re definitely not losing the soil,” one farmer remarked in response to a question about the economic value of no-tillage. This finding seems to support previous research suggesting that in some ways, larger farms may be considered more sustainable in their practices because they are more economically-minded (Lasley et al. 1993). It may be possible that larger-scale family farms may also be less likely to receive outside social pressures than smaller-scale farms.

Similar social references were observed in response to interview questions about cover crops. For example, one farmer remarked: “I guess I haven't seen too many people that do it yet so I might wait until other people do it." Another farmer responded to a question about considering cover crop use by saying, "Haven't really thought about it I guess…It's just kind of just starting around this area, this last year." These quotes illustrate how farmers reference their soil conservation decisions in relation to those around them.

Discussion

This study employs a binary logistic regression to test the roles of family and social pressures on soil management practices. Results indicate that social learning processes occurring in proximate geographic locations are a mechanism by which farmers bring the past forward to reference their soil management decisions. While much of the research on farmer decision-making to date has focused on individual-level factors associated with conservation adoption, this study provides the first quantitative evidence suggesting that social norms and pressure influence how individual farmers make decisions about the use of soil conservation practices. This suggests that agricultural soil management practices, such as post-harvest tillage, may not stem from agronomic rational alone; rather, social and cultural norms provide context to justify (or not) the use of certain practices. This supports the temporal reference framework and the role of historical intergenerational influence in agricultural decision-making.

The selectivity of historical family norms and pressure which are reinforced (or not) through the process of social learning is a complex topic. Other than family intergenerational cultural influence predicting significant decrease in cover crop usage, none of the other family intergenerational analyses provide significant outcomes. This does not seem to coincide with previous literatures suggesting the prominent role of family influence in agricultural decision making (Gould et al. 1989; Salamon 1992; McMillan 2015). There may be several reasons for this. First, perhaps family influence is so prominent in Iowa farmer decision-making that it flattens any variability between the survey respondents in the data. It is possible that intergenerational family influence is so ubiquitous across the sample that no variance was detected in the statistical analysis. Second, it is possible that geographic and social variability across the state of Iowa skewed the analysis of state-wide data. For example, farmers in the Driftless region of Northeast Iowa may be responding to very different geographical and social feedback signals that farmers in the North-Central "prairie pothole" region of Iowa. Recent research has found that "farms, farmers, and farm communities are too heterogeneous to represent with a single model" (Carlisle 2016:609).

There may be several interpretations for why social pressures are shown to inhibit soil conservation practices by influencing increase in fall tillage and decrease in cover cropping. Previous research to understand farmer identities segments four distinct groups: productivist, conservationist, civic-minded, and naturalist (McGuire et al. 2015). McGuire et al (2015) found that the civic-minded farmers responded in the opposite direction of productivists and conservationists on policies for soil and water conservation. McGuire et al. (2015) conclude by questioning, "Was the Civic-minded identity activated by group values and norms that are invested in the current voluntary system?" Civic-minded or community oriented individuals would be assumed to have stronger neighbor and family-oriented values. If this assumption holds true, it appears that social values and norms may be invested in current soil management systems that reinforce traditional soil practices such as fall tillage and inhibit "new" or emerging practices such as cover crops.

Neumann et al. (2007) provide further explanation to understand the role of family influence and barriers to adjustments in soil management practices. "When a farmer is connected with the previous generation (usually via the father), his or her own way of doing things is anchored in established, traditional methods, and thereby limited in the potential for innovation" (Neumann et al 2007:114). They continue by suggesting that "Intragenerational connections (e.g. between siblings) may also serve to maintain traditional values because of the reinforcement of familial ideals among peers." This "preservation of values," Neumann et al (2007:114) argue, "may then lead to reduced innovation."

However, Abd-Ella et al. (1981) study of Iowa farmers found the opposite: farmers with stronger family goals were more likely to try innovative farm management techniques. It is suggested that increasing valuation of family farming will have a positive influence on adoption of agricultural practices (Abd-Ella et al. 1981). However, Carlson et al. (1994) conducted a longitudinal study of conservation attitudes and behaviors from 1976-1990 and concluded that farming with a relative was a positive predictor of erosion control practices in 1976, but that this influence significantly decreased over time. It is possible that large-scale transformations of the agricultural industry, such as the farm crisis of the 1980's, have adjusted how farmers conceptualize and make decisions relative to the "family farm."

It is clear that family influences farm decision-making, although questions remain to what extent family influence increases or decreases willingness to adopt conservation practices. So, the question remains: are family farm long-term goals to remain flexibility and resilience in the face of extreme weather events and climate variability? Or are these goals rather to maintain the "status quo" or agricultural production as it has been performed by ancestors and become engrained in generational heritage? To address this question, future research might focus on how intergenerational influence impacts the perception of time scales to coincide with (1) socially-referenced time that reinforced the cyclical nature of natural systems and appropriate decision making, and (2) objectively-referenced time that recognizes and responds to early warning signals which indicate a transformation from one "steady state" natural condition to another? Chapter 5 will further explore this issue.

Conclusion

This study provides evidence that social pressures do influence soil conservation decisions. In particular, social pressure appears to be negatively associated with decreases in the practice of fall tillage. While it may be assumed or argued that soil conservation results from agronomic or economic rationale, this study indicates that social pressures at the family- and neighbor-level do impact the decisions farmers make about tillage and cover cropping. As expected, stewardship ethic is positively associated with decrease in fall tillage and increase in no-tillage and cover crops. Farm revenue is positively associated with decrease in fall tillage and increase in no-tillage.

Quantitative evidence supports the hypothesis that social pressures are influential to the use (or not) of agronomic-recommended soil conservation practices. This suggests that simply increasing our scientific understanding, or institutional knowledge, about the risks and benefits of certain tillage and cover crop practices may not be enough to drive major change across the landscape. Rather, more attention should be focused on understanding the processes of social learning and how intergenerational family influences and social pressures on farming management impact decisions over time. Unlike the diffusion of hybrid seed corn technology in Iowa in the early 1900's (Rogers 2003), soil conservation strategies do not appear to be "percolating" through opinion leaders, early adopters, late adopters, and laggards. On the other hand, early adopters of soil conservation practices may still be considered by family and farmer peer groups to violate social norms about how agriculture is performed in Iowa.

A limitation of this research is the interpretation of the dependent variables responses. The data do not tell us what the current use of the three soil practices are, and thus we do not know what the farmers' decision to increase, decrease, or remain consistent with current use of the three practices means. In other words, a response could indicate the farmer either is doing the practice and has not changed, or the farmer is not doing the practice and has not changed. If the farmer is already using cover crops or no-till practices on all their lands, remaining the same would be beneficial to increasing soil health, however, if they are currently only doing fall tillage, remaining the same could lead to increased wind and water erosion over the fallow period.

To refine our understanding of this topic, future research should further parse out the multiple levels of family influence, such as those from parents, siblings, grandparents, and extended family. Further, spatial modeling techniques could be employed to determine if family influence is geographically variable, or if heterogeneity in farming population is evident throughout regions across the state. This would help further compartmentalize the complex role of family influence in soil management practices in annual corn-based cropping systems.

Results of this research may help scientists, extension educators, and other agricultural stakeholders more effectively diffuse information through social networks. Learning events and field days are an increasingly successful and effective way to transfer information through farmer groups (e.g. Iowa Learning Farms). At a recent soil health conference, an extension educator and agricultural professional suggested bringing back the idea of "no-till clubs." These "clubs" are informal, networks of people that act as "information facilitators" to disseminate information to other farmers throughout geographic locations. In this way, a new process of social learning using modern technologies of connecting people via webinars, social media platforms, and other communication exchange mechanism could circumvent some family and community pressures that seemingly restrict farmers to perpetuate traditional practices of intensive soil tillage.

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CHAPTER 5.

NATURE AS MUSEUM: HOW SOCIALLY-REFERENCED TIME INFLUENCES PERCEPTIONS OF ENVIRONMENTAL STABILITY

A paper to be submitted to *Rural Sociology*

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Abstract

Human perceptions of time remain understudied drivers in social science literature of natural resource decision-making. Agricultural land management decisions in particular are often weighted with a *temporal reference* that gives preference to historical knowledge and social norms over expectations of future scenarios. This paper utilizes a temporal reference matrix to examine relational/cyclical time and sequential/linear time in conjunction with past and future orientations to understand how perceptions differentially activate knowledge systems to inform decision-making and action. Of interest is the extent to which agricultural traditions and historical narratives relate to perceptions of changing climatic conditions over time and managing agricultural lands. Analysis of interviews conducted with a purposeful sample of 159 Midwestern corn-soybean farmers and 22 climatologists in the North Central Region of the United States suggests that temporal pathways and temporal orientations play prominent roles in views of natural systems and decisions about managing them. This study reveals that farmers' historical experiences may influence the formation of beliefs about climate impacts to agriculture. Further, decisions about the natural environment in agricultural contexts seem to be evaluated by farmers in relation to socially-referenced time scales that privilege experiential/subjective knowledge systems. This contrasts with the experimental/objective knowledge of climate and agricultural scientists that is often communicated in linear frames of time. As a result, a disconnect in temporal references between scientific and agricultural audiences may not only differentially affect how scientific information is interpreted but also how it is applied in the process of decision-making. Socially-referenced time draws largely upon past experiences and historical narratives that are embedded in rural communities and kinships. Thus farmers may perceive nature as an unchanging continuation of family legacy. This can

influence perceptions of the natural world as steady state with assumptions of environmental stability, or nature as a museum.

Introduction

Human perceptions of time are understudied drivers of individual and collective decision-making in social science literature (Luscher 1974; Bergmann 1992; Adams 1995: Zeitlyn 2015). Despite evidence that temporal orientation is a significant predictor variable for support of climate change policy (Dietz et al. 2007), the temporal component of natural resource conservation adoption continues to receive little attention from researchers (Reimer et al. 2014). As sociological analysis becomes an increasingly valuable tool for understanding human adaptation strategies to climate disruption (Dunlap & Brulle, 2015), it is important to actively reconsider and assess the role of temporal orientation in conservation behaviors. The intent of this paper is to advance our knowledge and strengthen the toolkit of social science researchers and natural resource practitioners to recognize, understand, and document how temporal orientation impacts farmers' willingness and capacity to develop long-term strategies that ensure environmental and economic resilience for future generations.

Drawing upon the temporal reference framework (Wilke & Morton, 2016), this paper explores two ideas: (1) Socially-referenced experiences are formative in developing temporal orientations, and (2) How people perceive their decisions to resonate through time guides actions that impact agricultural and natural resource management. Building upon the concept of a temporal fulcrum—or temporal orientation—(Raedeke & Rikoon, 1997), it is postulated that as humans assess decisions and actions, differential weights are placed upon past personal experiences and intergenerational narratives ("past orientation") and future expectations or desired outcomes ("future orientation"). Further, knowledge systems which provide foundation for the development of temporal orientation are referenced through the process of social learning. In other words, humans look towards others within an immediate social group to give meaning to past experiences that could guide future orientations. In this way, concepts of nature and the utility of natural resources are developed in relation to self-identified social reference groups (Kahan et al. 2011).

This paper extends the temporal reference framework proposed in Chapter 3 by delineating four time quadrants (past orientation, future orientation, cyclical time pathways, and linear time pathways) which farmers and climatologists may use in their interpretation of information and application to decisions (see Figure 4.1).

Data from in-person interviews with farmers (N=159) and climatologists (N=22) in the North Central Region of the United States provide evidence to further explore the temporal reference framework. Drawing from previous research (Raedeke & Rikoon, 1997; Riley, 2008), the concept of temporal reference postulates that past oriented and socially-referenced time perceptions are a dominant form of temporal reference among Midwest farmers. This understanding of time reference in rural agricultural contexts may provide new evidence to strengthen the ability of social science for clearly measuring and documenting the role of temporal orientation on human behavior. Further, understanding time pathways and their influence on decision-making and action in the rural farming population may help us better develop and implement effective communication strategies to provide advancing agricultural and climate science for decision support.

Temporal Pathways

Durkheim famously argued that human time cognition and conceptualization of time has social origins and is socially determined. Time, he claimed, is a "collective representation" of commonly shared symbolic meanings within society (Durkheim, 1959). Periodizations—such as weeks and years—do not exist in the outside world, but rather reflect human interpretation of external reality. The idea that cultures may live in different temporal dimensions has been termed "temporal cultural relativism" and applied through anthropological investigations of "modern" and "traditional" cultures (Gell, 1992). According to Gell (1992:13), "the world is a process which goes on in time; different cultures may posit entirely different pictures of this process, and in that sense, occupy different culturally-constituted 'worlds.'"

Following in the steps of Durkheim, social anthropologist Edmund Leach constructed a theory positing the concept of time as involving two experiences of human life. The first involves the cyclical nature of time pathways. According to Leach et al. (2000:125), "certain phenomena of nature repeat themselves." The second describes time pathways as a linear pathway or that "life change is irreversible" (Leach et al. 2000:125). As a result, human conceptualization of time conflates these two basic experiences of life. Society and religion describe time as both a process of irreversible change (e.g. life leads to death), and as a cyclical or repetitive process of constant rebirth (Gell 1992). These two fundamental conceptualizations of time are central to human perceptions of time.

Cyclical time

Accumulated knowledge in the form of memory acts as “experiential grounding” to provide human capacity for “anticipating and envisioning future uncertainty and surprise” (Tschakert & Dietrich, 2010:11). It has been documented that collective memory influences community response and perception to environmental risks and hazards (Messer et al. 2015). In other words, socially-referenced community connections influence the perception of time and the cultural appropriate time scales to achieve certain outcomes (Crow & Allen 1995). Giddens (1984) extends this idea by arguing that society is structured based upon routinization and repetition of social actions. According to Bergmann (1992:99), “Methodologically, this means that one can infer the time concepts and value systems of societies from their types of time measurement.”

There is evidence to support the prominence of cyclical time pathways in rural agricultural contexts. For example, Riley (1998) studied the adoption of environmental friendly farming practices in hay-meadow management. It was discovered that “Farmers, particularly the large majority with a long family history on their farm, projected a narrative of continuity that accentuated the long-term, continuous, and unchanging nature of their occupancy and management” (Riley 1998:7). Riley (1998:7) continues by describing how the past was “being cast as inseparable from the present and current farmers being inseparable from forebears who had farmed the same land. This was achieved and underpinned by drawing on a compressed temporal framework with the use of phrases such as ‘we farmed’ and ‘our history of the farm’ allowing current and previous generations of farmers to become synonymous.” This suggests that rural farmers demonstrate temporal pathways highlighting the repetition and cyclical nature of the farming operation (Riley 1998). Farmers arguably are the stewards of earth’s history and are thus more likely to embrace and maintain this history. On the other hand, farmers reported the linear and consistently changing nature of scientific recommendations by expressing apprehension about how “scientists keep changing their mind” (Riley 1998:7).

Linear time

Raedeke and Rikoon (1997) argue that different cultures of knowledge have different perceptions of time and attitudes regarding change. They suggest that as opposed to traditional agrarian cultures, “Scientifically oriented knowledge cultures are more readily suited to accommodating revolutionary change in which new understandings (or paradigms) may overwrite, or break from, the past” (Raedeke and Rikoon 1997; Riley 1998:4). This is consistent with modern understandings of scientific knowledge development, in which paradigms and theories are iteratively revised and updated to replace prior knowledge (Kuhn 1962).

Linear time pathways may be perceived to be more rational, progressive, or “modern” (Schulz 2012; Bloch 1977). Cyclical time is regarded as a more traditional and conservative form of time pathway. Rejection of tradition is a principle often associated with liberal thought process (Kirk 2001). Linear time pathways allow and support deviation from established norms (Luscher 1997). In this way, linear time pathways often weight future time orientation more prominently than past time orientation (Luscher 1997).

Temporal Orientation

Time is a common thread intertwining the concepts of climate, agricultural production, and human decision-making. Climate is conceptualized as the distributions of weather (measured on short-term scales such as hours or days) over long-term time periods of decades or centuries. Production of agricultural corn and soybean crops occurs along a time-scale that is seasonally determined and directly dependent upon favorable weather (in the short-term) and climate (in the long-term). Human decision-making relative to these two concepts likewise involves a prominent time component. An unspecified and adaptable time scale constantly occurs between human experience of some biophysical or social condition, reference to knowledge systems and values for decision formation, action to execute the decision in the external environment, and outcome or adjustment in some future biophysical or social condition. For example, a farmer may experience a longer growing season, assess experiences of other peer farmers and recommendations from climate science to consider a longer season hybrid seed, plant corn two weeks earlier than "normal" or previous planting period, and expect a longer growing season and increased yield. The formation of temporal orientation in the agricultural context combines (1) beliefs of climate change and causality and (2) sustainability for future generations.

Describing a typology of climate adaptation options in agriculture, Smit and Skinner (2002) recognize the temporal balance of agricultural decision-making. For instance, they remark that "Timing of adaptation differentiates responses that are anticipatory (proactive), concurrent (during), or responsive (reactive)." They continue by suggesting that while these timings of adaptation response seem logical, in practice the distinctions are much less clear-cut. For example, a farmer who experiences several droughts (reactive) may come to expect frequency of drought to remain consistent or continue to increase in the future (proactive) (Smit and Skinner, 2002). As a result, an adjustment in management practices in response to drought risk activates both reactive and proactive time references.

Luscher (1974) provides a foundation for which we may conceptualize and begin to measure these time-referenced sources of adaptation response. Two primary modes of human temporal orientation are proposed: (1) "*Because of*" motivations result from past-orientation to personal experiences and historical cultural norms which provide a blueprint action, and (2) "*In order to*" motivations guide future-orientation and foresighted behaviors to achieve a future scenario or outcome. More recently these two distinct modes of human motivation have been explored and applied for marketing and advertising research. According to Zeitlyn (2015:384), central components of human time experience are the existence of "retentions—memories or traces of the past—and protentions—projections or anticipations" into the future. For this study, the two primary pathways for temporal orientation are composed of future orientation and past orientation.

Future orientation

To assist the Washington International Center in intercultural education and immersion for foreign diplomats, Kohls (1984) developed 13 commonly shared "values Americans live by." One of these shared values is future orientation. "Americans have traditionally been hopeful that the future would bring even greater happiness," Kohls (1984:4) states, "Almost all energy is directed toward realizing that better future." Americans are also said to "devalue the past and are, to a large extent, unconscious of the present" (emphasis in original) (Kohls 1984:4). This observation of placing priority on forward-oriented thinking seems appropriate to modern American culture and is reflected in literatures of framing messages congruent with American values (Schultz and Zelezny 2003). Much of our small talk and social engagement with others primarily revolves around the topics of *"What are you going to do tonight or this weekend?"* as opposed to, *"How was your last night or weekend?"*

This preference for future orientation is often considered to guide our collective decisions about public policy. Gomen-Pompa & Daus (1992:271) claim that "Environmental policies and education reflect a collective perception of nature, the consolidation of what is held to be true about the natural world and what is necessary to pass on to future generations." Long-term decisions for the sake of future generations are a prominent theme in the concept of natural resource sustainability (Wade-Benzoni 2008; Willis & Birks 2006). For instance, a common definition of sustainable development describes it as meeting "the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987:8). However, it is necessary to recognize that "dealing with the future is clearly a value question" and "our preferences depend on what we believe about how actions will affect things we value" (Dietz, 2013:14082). History and orientation to the past provide reference to which we gauge and judge our individual and collective values in relation to future outcomes. Humans make decisions—even future orientated decisions—by looking "through the lens of their preexisting values" (Moser and Ekstrom, 2010:22029).

Past orientation

Kohls (1984) observed that past orientation is reflected in the values of many other countries and cultures who embrace traditions and rituals. Often cultures with past orientated values are directly connected to the natural world through subsistence food production and provisioning amongst spatially local community members. Previous research suggests that communities have different time orientations (Crow et al. 1995). For instance, urban and/or technologically-intensive communities lean towards future orientations, while rural agrarian communities lean towards traditions and past orientations. This is particularly interesting to consider in relation to the environmental influences of human development. Anxiety—a human emotion provoked by uncertain anticipation of the future—has been demonstrated to manifest significantly more in urban populations that rural populations (Grupe et al. 2013; Lederbogen et al. 2011; Peen et al. 2010). This suggests, as Smith and Zopf (1970:493) state, that "to a considerable degree, farmers differ from urban people because of the differences in the cultural influences impinging upon them."

The temporal reference framework posits that historical past events influence farmers' assessment and adaptive response to climate risks. Chapter 3 developed and proposed this theoretical framework using the narrative of "analog" events, or something analogous or similar to something else. Analogous situations are described as transformative biophysical events, such as extreme weather and climate that creates risks from excess water or drought. Narratives, or socially-relevant stories about these events, are also referenced as they are passed through generations of farm family heritage. However, it remains unclear to what extent these socially-referenced narratives impact the formation of temporal pathways and its relation to future orientation and past orientation. The intersections of temporal orientation (past and future) and temporal pathways (cyclical and linear) are critical to examine in order to better understand the differences between socially-referenced traditional knowledge systems and objective scientific knowledge systems.

Temporal Reference Matrix

Previous research suggests that members of the scientific community rely on experimental or objective knowledge that assumes and communications timescales in linear or sequential frames (Raedeke & Rikoon, 1997; Riley 2008). Likewise, scientific knowledge development prioritizes the iterative process of discovery and replacement of new paradigms (Kuhn 1962). On the other hand, farmers and others embedded within rural communities privilege experiential or subjective forms of knowledge which consider time as a cyclical continuation of historical rural legacies (Riley 2008). Further, this experiential knowledge is socially-referenced to established norms and social pressures which guide behavior. To investigate these various components of temporal orientation and perception, a heuristic matrix of four temporal references categories is proposed (Figure 5.1).

	Past orientation	**Future orientation**
Cyclical time	Intergenerational narratives referenced to social (family) relationships	Modifying established cultural expectations and norms
Linear time	Steady state continuous and irreversible personally experienced social and biophysical events	Continuous discovery and experimentation

Figure 5.1. Temporal Reference Matrix. Temporal orientation (past or future) and temporal pathways (cyclical or linear) influence the development of temporal reference. These four quadrants suggest the predominant role of influence in developing knowledge systems to provide foundation for guiding decisions and actions. These quadrants are fluid and individuals may reach from multiple influences to inform decisions for achieving desired outcomes.

This matrix applies the temporal reference framework to explore how temporal orientation and pathways impact perceptions of change. In this case, the concept of change is applied broadly and may include concepts of changing climate over time, changing environmental risks or extreme weather, or changing decision-making processes such as agricultural management. These quadrants are developed with assistance from the literature reviewed above, as well as the temporal reference framework described in Chapter 3.

The first quadrant combines past orientation and cyclical time pathway. An individual with this type of temporal reference is posited to assess change relative to intergeneration narratives which are referenced to social relationships. This primarily socially-referenced quadrant is strongly guided by family-level influence. Combination of future orientation with cyclical time pathway, the second quadrant, results in an assessment of change in relation to modifying or deviating from established cultural norms and expectations of behavior. By prioritizing future orientations, individuals with cyclical time pathway are tasked with considering historical analogous events as they envision and work towards understanding or enacting future changes.

The third quadrant combines past orientation with linear time pathway. In this quadrant, individuals perceive time as continuous and irreversible, yet are constrained by orientation to past experiences and narratives of historical events. As a result, this quadrant is more apt to perceive past states as continuously moving forward in time, resulting in perceptions of change as a form of continuation of previous events. The fourth quadrant, future orientation and linear time pathway, describes individuals who are the most comfortable accepting the process of change. This quadrant approaches change through an iterative process of discovery and continuous experimentation to refute or support past understanding.

To determine the quadrants upper Midwest corn farmers occupy in their assessment of changes in climatic conditions and adaptive management practices, 159 interviews are analyzed. Twenty-two interviews with state and extension climatologists in the upper Midwest provide data to explore how climate scientists perceive climate causality and the intersection of climate and agriculture. This research study explores the questions: How do upper Midwest farmers' temporal orientation and temporal pathways influence perceptions of climate change and sustainability? How does this compare to a sample of upper Midwest climatologists? Given the prominent role of historical narratives and past personal experiences described in the temporal reference framework (Chapter 3) and the influence of social norms and pressures (Chapter 4), it is posited that socially-referenced past orientations will dominate how farmers perceive climate change and agriculture. Further, building upon the literature described above, it is posited that socially-referenced time perception will evoke notions of time as cyclical and repetitive.

The next section describes this sample and methodology for analysis. Results from the analysis including selected representative quotations are then presented. Discussion and concluding remarks describe what this means for the temporal reference framework and how it may assist climate science communication efforts for reaching the population of upper Midwest corn farmers.

Methods

Data were obtained from in-person interviews with upper Midwest corn farmers in 2013. These 159 interviews spanned a nine-state region, including Illinois (9), South Dakota (14), Missouri (16), Ohio (18), Indiana (20), Iowa (20), Minnesota (20), Michigan (20), and Wisconsin (22). Purposeful sampling was employed to recruit farmers who have connections to land grant university extension educators. These farmers are a unique sample in that they are more likely to have tried or are currently using conservation-oriented practices. The sample is comprised of large-scale corn and soybeans commodity producers. Farmers with more than $100,000 in gross farm income in 2011 account for roughly 80% of the cultivated land in the North Central Region of the United States (Tyndall et al., 2015).

Interview questions and prompts were collectively developed by a team of scientists involved with the “Sustainable Corn,” or Climate and Corn-based Cropping Systems Coordinated Agriculture Project (CSCAP) project (APPENDIX A). Extension educators assisted in conducting in-person interviews in their local regions. Interview protocol involved sections on experience with weather variability, use of conservation management practices (e.g. cover crops and no-tillage), sources of climate and agronomic information, thoughts about agricultural sustainability, and beliefs about climate change. This study was approved by Iowa State University Institutional Review Board #12-473 (APPENDIX B).

The farmers comprising this purposeful sample are often early adopters of conservation practices, tend to be more conservation oriented, and do not necessarily represent the entire spectrum of corn farmers. This sample was recruited to reach farmers who had some exposure and experience with key conservation practices. Further, they may have surmounted barriers or experienced challenges when adopting these practices. This sample of farmers may also have direct exposure to and experience with climate risk information and its usefulness and usability for farm management planning. Family members and farm partners were also invited to participate in the interview session if they desired. For a more complete and detailed description of methods, see Roesch-McNally (2016).

Interviews transcripts were analyzed line-by-line and coded for major themes independently by two researchers. NVivo qualitative analysis software assisted in coding and quantifying themes (NVivo, 2010). The average means of inter-rater reliability values for the farmer interviews range from 0.825 to 0.928. Krippendorff (1980) concluded that values greater than 0.8 indicate good reliability (Carletta, 1996). As a result, our lowest inter-rater reliability values of 0.825, 0.826, and 0.844 indicate good reliability of coding between our two interview transcript analyses. For the climatologist interview transcript analysis, Cohen‘s kappa values were all greater than 0.866 (Wilke and Morton 2015b). Development of a qualitative analysis code book (see APPENDIX D) guided analysis and assessment of concept frequencies to further refine and parse concepts (MacQueen, 1998; Miles, 2014). This analysis focuses on two specific interview prompts. The first explores the conceptual theme of "View of changes on the land." This theme is measured by participant response to the following prompt and questions: "There have been a lot of discussions lately about global climate change and its potential impacts on agriculture. (1) What are your opinions about climate change? (2) What concerns, if any, do you have about potential impacts on your farm operation?" Responses to this prompt were coded on the following spectrum: 1 = Steady state, status quo, no changes detected in climate or concerns about farm operation; 5 = Response not clear or ambiguous; 10 = Dynamic, always changing. Data were recorded and analyzed using Excel spreadsheet analysis software. The second qualitative data point are farmers' response to the prompt, "Describe what on-farm sustainability means to you."

Eleven state climatologists and eleven extension climatologists (N=22) were purposefully selected to represent main outlets of location-specific and publicly available climate information in the upper Midwest. Climatologists were contacted by e-mail, given details about the research, and asked to participate in the study. All 22 climatologists agreed to participate in the study and were interviewed in the spring of 2012. Interview protocols and informed consent documentation were approved prior to administration by Iowa State University Institutional Review Board (IRB) #12-022 (APPENDIX C). See Wilke and Morton (2015a,b) for a more detailed methodology of the climatologist study.

Results

Qualitative data provide evidence to explore farmers' perceptions of changes in agricultural production systems relative to climate and weather. Climatologist interview data support the short-term time scales of farmer decision making. As one climatologist in Nebraska remarked, “I don’t really know how much, once you get into the climate scale, how much people really pay attention to those or use those in their operations.” They continue by remarking, “In my opinion, I don’t think [climate] factors in very much, because most people, as I understand it, are pretty focused on just within season and the next season.” A climatologist from Michigan provided a similar theme: “Another common comment…I’ve hear this one many times: ‘Why should I care about what happens 50 years from now? I have to worry about being in business next year. And, sure, scientifically, it’s an interesting thing, but I just cannot use it in my management decision because I have to worry about now.’” A South Dakota climatologist remarked, “I don’t know if they request much from a climatologist. They request more from a meteorologist, like ‘what’s the forecast for the next three days? What’s the forecast for the next ten days?’…Most of their decisions are fairly immediate.” This evidence suggests that farmers are not likely to consider agricultural decisions in response to climate change on a long-term future oriented time scale. Rather, farmers often focus on past events to contextualize climate change and agriculture.

Past orientation and cyclical time. Several remarks to the prompt “What are your opinions on climate change?” evoked a past orientation and cyclical time pathway. For instance, a Wisconsin farmer explained:

> “But we've had other periods of time, if you go back in history, where there've been winters that were mild, you know, for half a dozen years at a time or so forth and…I think weather oscillates. I think it follows a predictable, repeatable cycles and I haven't seen, really, evidence to the contrary.”

This suggests that past cycles are referenced to understand and explain current conditions. A Michigan farmer conveyed a similar observation: “I don't see the weather as being different than it was 5 years ago. It's different but it's always been different. We have cycles and this is the one we're in.” An Indiana farmer evoked analogous memories of the historic dust bowl of the 1930’s. “I kind of think it runs in cycles too…Our weather and stuff runs in cycles, cause, you know…All through the years, even in the '30s…So I think the weather kind of runs in cycles.” An Illinois farmer elaborated on historical analogies to contextualize current conditions:

> “I think this living planet of ours goes through cycles. I mean, there've been a couple different Ice Ages and really hot, parched times and, I remember, as a kid, growing up in the '60s, my gosh, summers that were hotter than anything we've had lately. And we survived those....I think that seasons change, temperatures change and, I think the cycle's, actually, starting to turn back the other way now and I think that's why we're experiencing the more volatile weather right now. And [extension educator] said he expects a more normal spring this year. So I don't know. I'm not a believer in human induced climate change and the only thing it's affected on us is timing.”

Several remarks also provide evidence about how family-reinforced historical narratives about weather and climate reinforce current climate change beliefs. For instance, a farmer in Ohio remarked, “It might be climate change, but…we got a couple warm years, then we get a couple cool years. I got to remember grandpa saying—like in the early 1900’s—they had a year it snowed every month. So sure wasn't global warming then.” This suggests that past changes reinforce the perception that climate is always changing. An Indiana farmer similarly evoked analogies of past climate conditions relative to family narratives and concluded, “I think [climate] just works in cycles. And my uncle Frank talked about how dry it was in the '30s.” An Illinois farmer conveyed past orientation while transitioning toward linear conceptions of farm continuation:

> “I don't exactly understand what [scientists] mean by sustainability. We have farmed part of this land, John's farm, for 60 years. We have taken care of it for 60 years. What now has changed that we're not doing what we're supposed to be doing?”

Past orientation and linear time. The conceptual quadrant of past orientation and linear time is less evident in the farmer interviews. One Iowa farmer remarked, “I honestly don't know if that'll help because I just think, in general, farmers will do what they've been doing for a long, long time and, if it's working for them, I think they'll continue to do it.” This suggests the perceived desire to continue managing agriculture in a way in which it historically has been performed. An Ohio farmer paralleled this thought: “I kind of like to tend to believe [climate] is more the cycle than it is man doing it, you know. As far as changing anything—we're gonna try to stay the same. We're going to try to maintain the same rotation we're used to.” This suggests, as described in Chapter 3, a desire to “bring the past forward.” An Iowa farmer provided an elaborate analysis of how past weather data is insufficient to predict future weather and climate:

> “Technically, we're still in an ice age because there's still ice caps year round. And so, if there is climate change, we can't do anything about it because we're coming out of an ice age. And humans have only been around for a couple hundred years farming the way we have been. I have another theory that the National Weather Service, it only started collecting data in what, like 1875? So that's only like 140 year’s worth of data which is a geological blink of an eye. I think that, perhaps, the Midwest and North America were settled in a very mild time, from the 1880s on, until the 1970s when all this data was collected. What are the chances that this extreme weather we're having now was the norm for the since the last ice age ended? So, perhaps, maybe this extreme weather, all the tornadoes and stuff, which tornadoes could be due to better reporting too, and a denser population, you know, scattered out. But, anyway, this extreme weather, hot, dry, maybe it was always like this and the last 150 years was just when we all settled it and took all this data. Maybe that was a very mild window in time. It's possible. I don't know. We don't have near enough data to, I feel, to jump to conclusions and human kind to say am I bad, we screwed it up again.”

Future orientation and cyclical time. While many farmers did not explicitly mention future orientation in describing climate beliefs, there was common reference to the cyclical nature of time as evidence to inhibit future orientation. A South Dakota farmer stated: “I don't believe in global warming…I mean, there's ups and downs and there's no way to predict one way or the other.” This perceived cyclical nature of weather was often described as a barrier to belief in future climate change projections. As Iowa farmer remarked on the possibility of future climate change with reference to cycles: “everybody thinks [climate] is a big change but, when you look at the history of this world, who knows how many years it's really been here and that pattern might take 10-15 years to reach a pattern itself and go through."

Climatologists recognized the hesitance of farmers to move from understanding natural variations in climate conditions to placing causality on human actions. For instance, an Iowa extension climatologist remarked: "Of course the farmer doesn't like the term 'climate change.' They all know that the climate is always changing, it has always changed, and it will always change….So they talk about climate changing, and they know it always has. They don't take too kindly to the concept of 'yes, but not it's changing faster than usual because of us.'" This suggests that farmers are reluctant to move towards the fourth quadrant on the topic of climate change belief. On the topic of sustainability of soil resources for future generations, however, farmers seem more willing to engage in conversations about future-oriented adjustments to current states.

Future orientation and linear time. There were no detectable references to the future orientation and linear time quadrant in response to the beliefs about climate change among the farmer sample. However, in response to the question "What does on-farm sustainability mean to you?" several farmers made remarks that implied the desire for alternative future conditions. One Iowa farmer remarked that to maintain sustainability, they must do "everything we can do to try to promote saving soil for the future." A farmer from South Dakota articulated how sustainability is to be "Farming the ground so it's in as good of shape in the future as it is now…so future generations can make a living at it as we do." An Ohio farmer remarked: "I like to think that this good Wayne County topsoil is going to around for future generations." This quote illustrates two concepts that appeared prominent any future oriented remarks: the importance of preserving and maintaining (1) soil health and (2) resources for future generations.

A farmer from Indiana connected these concepts by responding that "My job is to take an acre of ground, keep in in a productive level with conservation practices on it that's going to make the soil worth something more for future generations." This implies understanding of changes necessary in current management for the betterment of soil resources for the future. Another Indiana farmer paralleled this thought by directly stating: "I want to take care of my land for my future generations, for my son to farm, for his new baby to farm." These quotations suggest that for farmers to move towards future-oriented thinking and planning which deviates from historically-established practices, the conversation must move beyond simply the topic of climate change and encompass topics of sustainability, soil, and future generations.

Discussion

While ecological science acknowledges the possibilities of shifts in environmental conditions or states—including early warning signals when change threatens the current state shift to alternative stable states (Beisner et al. 2003)—social science has been relatively absent from applying these resilience concepts for understanding changes in human decision-making. As Collins et al. (2011) point out in proposing an “integrated conceptual framework for long-term social–ecological research,” “the model assumes a continuous cycle of human decision making.” As a result, human perception and interpretation of time remain somewhat of a “black box” in ecological science.

Results of this analysis begin to open the box and explore how human time perspective—involving both temporal orientation and temporal pathways—influence perceptions of environmental adjustments and changes in climate. It appears evident that the sample of farmers maintains historical connections to past environmental extremes, such as drought or extreme temperatures, to contextualize current and future changes. The reported influence of personally experienced past events and narratives of past events passed down through family in how farmers perceive and make decisions about current and future environmental conditions are evidence to support the proposed temporal reference framework. Further, this analysis sheds light into the observation of farmers as “bringing the past forward,” or seeking to maintain the legacy of agricultural production in ways in which it has been practiced by ancestors. The predominance of the cyclical temporal pathways among the farmer sample suggests that they may not be worried about future climate risks because their ancestors and themselves have always surmounted environmental risks.

This research supports the observation by Palmer (2012:5) that “future projections on the biophysical impacts of climate change…have had far less of an effect…than many scientists had hoped they would.” It is possible, as Renzo (2013:255) argues, that "Forecasts, particularly ones operating at large spatial and temporal scales (like climate forecasts), can act as discursive reformations: they project the past or the present over the future, but in a way that (atemporally) makes both the past/present and the future look and feel simpler, more stable, and more rationally organized." This may result in farmers and others within the general public being less concerned or prepared for adaptive action than if potential instabilities and disruptions to ecological states were better understood and acknowledged (Beisner et al. 2003; Weber & Stern, 2011).

Adger (2000:350) provides a notable observation that "The philosophical basis of managing the environment is determined by the world-view of nature where people managing resources conceive of the environment as either benign, balanced, or, indeed, resilient and able to reorganize itself." Farmer interview data provide evidence that historical references to transformative weather events—such as droughts and floods or fluctuations in temperatures—convey to farmers the idea of climate as always changing. This belief appears to reinforce the notion that since climate has always historically changed, for example during the 1930's when family ancestors farmed, then why should I be concerned about adapting to current and future conditions that will ultimately cycle beyond my control. Unlike many urban residents, farmers are embedded within the natural resource base of rural places and are the symbolic caretakers of land. "Every farmer knows this—that weather is the most important single uncontrollable factor in agriculture," conveyed an Iowa extension climatologist. But if farmers perceive weather, and therefore climate, as uncontrollable, to what extent will they perceive the need for appropriate adaptation to remain resilient during future climate projections?

Conclusion

To guide decisions and consider outcomes, human knowledge is placed within a social context (Carolan 2006b). As a result, communication of information should reinforce generational timescales of conservation, which activated both social (cyclical) time and past orientation. The following key lessons for agricultural and climate science communication efforts may be helpful to advance effective communication messaging strategies (Table 5.1).

Table 5.1. Key lessons for agricultural and climate science communication efforts (adapted from van der Linden et al. 2015).

Human tendency	**Communication strategy**
People prioritize experiences over analyses	Personal experiences through recall, stories, metaphors, narratives
People are influenced by group norms	Leverage and activate relevant social group norms to promote and increase collective action
Behavioral response is relative to proximate cues	Emphasize the past and present and make climate impacts and solutions local
People are risk averse	Frame information in terms of how it can increase benefits and reduce risks
Motivations seek to ensure long-term human survival	Leverage "intergenerational narratives" of conservation that connecting current individual decisions with future impacts to family

These communications strategies highlight several aspects of agricultural decision-making illustrated in this analysis and throughout the dissertation. First, individual human experiences and narratives or stories of past experiences are prioritized in the formation of knowledge and consideration of decision. Second, people are influenced by group norms at the level of self-identified reference groups, which often involves immediate family members. These two human tendencies combined highlight the profound influence of narratives passed on through family ancestors. Third, human behavior is responsive to cues which are proximate, or close to an individual. These cues can be spatially proximate and/or temporally proximate. This implies that climate change messaging strategies which emphasize long-term changes on scales of decades or centuries may not be as effective as highlighting changes that have already occurred and may occur in the more immediate future. Fourth, humans are naturally risk averse and respond to information that may help them avoid potential risks or hazards. Building from the previous strategies, this suggests that messages which describe how science has alleviated past agricultural risks may be well received. Lastly, humans seek to preserve and replicate their genetic and social heritage by supporting the success of descendants. Effective communication strategies may be achieved by framing climate science information relative to benefits for reducing risks to soil resources for future generations.

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CHAPTER 6.

GENERAL CONCLUSION

Implications

This dissertation addresses a gap in our understanding of the relationships among time perspective, perception of climate risk, and intergenerational narratives on adaptive farm management decision-making. Based on a synthesis of common themes in the literature and inductive analysis of in-depth qualitative interview data with upper Midwest corn farmers (N=159) and climatologists (N=22), a theoretical framework of temporal reference is developed. Quantitative analyses of 2015 Iowa Farm and Rural Life Poll data provide opportunity to test and refine the framework. Evaluating the influence of time perspective—including temporal orientation and temporal pathways—on other important predictor variables in farmer decision-making will help improve our theoretical understanding of motivation sources that inform the decision process, how they are contextualized in historical and future time frames, and the magnitude of biophysical and social feedback at four distinct time stations. This knowledge can be applied to further understand adoption rate of voluntary conservation practices, such as reduced tillage, on the Midwestern agricultural landscape. Further, findings may help scientists and other agricultural stakeholders advance effective communication strategies that appeal to farmer's motivations to be effective adapters and perpetuate farm productivity into the long-term future. This research will support science-based strategies that provide decision support to inform the development of educational materials, policy, and land use decision-making to adapt agroecosystems for resilience to future uncertain risks of extreme weather events and variable climate conditions. This will address the challenges of minimizing future climate risks to society, the economy, and the environment, and help ensure long-term food security and human well-being.

Climate scientists rely on observed historical weather and climate data to inform current and future climate model projections. Similarly, agricultural producers use historical events—recent past experiences and historical narratives—to construct local knowledge to assess, quantify, and manage current and future risks. These historical data, events, and experiences become reference points or analogs when compared to a current phenomenon that exhibits similar characteristics specific to past conditions. This suggests that:

- Historical weather events are used as analogs by farmers to assess future risks
- Farmer local knowledge emphasizes relational timescales of past experience
- Climate risk information should be conveyed along timescales which include the past

These findings have practical application for climate and agronomic scientists and other stakeholders who bridge climate science information and agricultural decision-making. A recent U2U-CSCAP report, "Climate Change and Agricultural Extension: Building capacity for land grant extension services to address the agricultural impacts of climate change and the adaptive management needs of agricultural stakeholders," suggests the need to "Talk about trends over time" (Morton et al., 2016). By doing so, climate risk communication efforts should not only rely on future-oriented or foresighted strategies, but rather incorporate a time range that includes temporal reference to historical events and past experiences. This may allow farmers to accept and utilize information about the compounding effects of soil management decisions over time, for example, to develop effective climate risk management strategies that ensure productivity and resilience of agricultural landscapes well into the future. By connecting climate science to agricultural traditions, we may better manage landscapes of the future.

At a recent Iowa watershed training event, a Soil and Water Conservation District (SWCD) employee was recalling a recent experience with three farmers at a local farm and equipment show. As the story goes, three farmers walk by the SWCD booth. Farmer #1 and Farmer #2 laugh loudly and remark, "Hey, Farmer #3, here are your pretty radishes!" Farmer #3 gets red with embarrassment, and the SWCD employee senses this farmer is being bullied by the other farmers. Immediately sensing the need to intervene in this social situation, the SWCD employee jumps up and runs over with printed literature about soil conservation management techniques. Before the farmers could mutter a word, a stream of information was presented about the benefits—both in-field and off-field—of cover crops, including cost sharing and economic analyses. There was a brief silence in which the faces of Farmer #1 and Farmer #2 turned red, while Farmer #3 slowly turned to them and confidently declared: "Yep, guys, those are my tillage radishes…they protect the soil, the water, and they're starting to save me money.

What are you doing to improve your ground?" The SWCD employee recounting the story referred to it as the most profound and effective moment of science communication they had witnessed. To this day, it was said, they make every effort to facilitate farmers conveying information to other farmers.

As society has transitioned off the farm and become more urban and mechanized, land-grant extension activities and efforts have transformed tremendously to accommodate the changing rural landscape. Because of this, rural communities which have historically been serviced by an agricultural extension agent may now only have access to one field staff located counties away at a regional office. While these individuals may be just as or more capable of providing relevant information to those who seek it, they are more often than not actually embedded within the community and known on a personal relationship level. As a result, their ability to transfer ecological knowledge through the social hierarchy of knowledge via social learning may be hampered. The question remains, how can scientists and extension educators diffuse emerging scientific knowledge to those opinion leaders who have social influence among late-adopters and laggards?

Limitations and future research

There are several limitations to this research worth noting. First, the purposeful sample of corn-soybean farmers (N=159) in the upper Midwest tends to be more conservation oriented than "average" Midwest corn farmers. They are early adopters of conservation practices and more than half are currently using or have tried cover crops and no-till. About a third of these farmers are operating integrated crop and livestock production systems, allowing for utility of perennial pasture crops and grazing or baling of cover crops. This sample of farmers may also have direct exposure to and experience with climate risk information and its usefulness and usability for farm management planning. Second, the sample of 2015 Iowa Farm and Rural Life Poll respondents (N=1,159) tend to be slightly older than average farmer age. Further, these findings are derived from farmers in Iowa and the upper Midwest whose cropping systems are predominantly corn-based. Perceptions of time may differ among farmers by region of the U.S. and globe, as well as by cropping systems.

Future research should further parse out the role of temporal reference and time perspective by various sub-groups of farmers. For example, are livestock farmers more willing and able to make longer-term management decisions than crop farmers? Are livestock farmers more or less influenced by past personal experiences and intergenerational narratives than crop farmers? Specialty crop production differs in many ways from corn-based systems; how do these producers perceive time in relationship to climate and their production systems? Does age matter? How do younger farmers differ from older farmers? Further, is there a difference between first generation, second generation, and multiple generation farmers in how they reference the past to inform decision making?

Other future research avenues may involve expanding the temporal reference framework beyond the farming population. For instance, to what extent do individuals reared and/or living in rural environments differ in time perspective than those reared and/or living in urban environments? Further, how does time perspective influence occupational choice? Along those lines, how may occupation influence one's perspective of time?

Conclusion

How humans perceive and reference timescales is a useful variable in understanding environmental behaviors. This dissertation draws from a sample of upper Midwest corn grain farmers to explore the role of temporal reference in agricultural decision-making.

Many conservation practices, such as reduced tillage and cover cropping, produce agronomic and environmental benefits that are compounding over time (Lal, 1993, 2002; Grandy et al., 2006). In other words, benefits of these management practices may not be realized within annual time cycles; rather, benefits accrue in longer-term time horizons. As a result, it may be challenging for a farmer or land manager to balance risks and benefits of farm enterprise economics, soil health, and carbon sequestration or increases in soil organic carbon.

Regional case studies that document peer farmer success over time may be helpful in communicating effects which are compounding over time. These case studies should include both current and past yield data, changes in soil organic carbon loss/gain, and water monitoring for nitrogen and phosphorous levels over time so that farmers can directly compare and create their own analogs from their personal past experience. By viewing soil data in relation to other fields within the watershed, for example, farmers may be more inclined to shift their soil management techniques. Measuring, monitoring, and evaluation of past field, farm, and watershed level activities by farmers involved in performance-based management watershed groups have been shown to change beliefs and knowledge of farmers as well as their practices (Morton 2008).

During the historical drought year of 2012 in the Midwest corn-belt, many no-till corn crops produced greater yield than crops in a continuous tillage system (Kumar et al. 2014). Viewing the agronomic data of peer farmers using conservation management techniques may allow farmers to develop analogous cognitive representations of their own management decisions in relation to their personally experienced climate risks, environmental conditions, and agronomic outcomes. By making comparisons to other regionally-relevant operations, farmers may better understand how certain management techniques, such as no-till, have performed over time and in different weather and climate conditions.

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APPENDIX A.
CSCAP FARMER INTERVIEW PROMPTS
Qualitative Farmer Assessment of Adaptive Management Protocol

I. Objectives

1. Understand barriers and facilitators of farmer adoption of major conservation practices that the CS CAP project is researching: nutrient management techniques; no/reduced-till; cover crops; extended rotations; and controlled drainage water management.

2. Understand beliefs about climate change and how those beliefs shape attitudes towards adaptation and mitigation.
    a. Understand farmers' perceptions of weather-related risks.
    b. Understand perspectives on what farmers and the companies, advisors, and agencies who work with them should do to ensure long-term productivity.
    c. Better understand who farmers trust for information regarding climate change and who they look to for assistance with conservation
3. Understand farmer perspectives on stewardship in the context of increasingly common extreme weather events.

II. Step-by-Step Procedure

1. Recruit farmers based on sampling protocol (80+ acres, try to recruit some women and a spectrum of highly conventional to organic producers) but stick to your quota.
2. Ask farmers to take the *Farmer Survey*, which they mail-in (follow-up to make sure they do).
3. Take the ***Interview 1: Farm-Level Data Collection*** *worksheet* with you to meet with farmer and conduct an interview about their farm. (See *Interview 1: Farm-Level Data Collection* section and Data Collection worksheet).
4. Identify two fields, one good and one marginal and get location information so that you can print a Google Earth map of the fields for the second interview.
5. Upload data onto the online data sheet that is found at the sustainablecorn.org website. Other management worksheets/Enterprise budget information will be designed at a later date.
6. Set up second interview time with farmer. This interview will take about one hour.
7. Conduct a semi-structured interview with each farmer (make sure you record the interview **AND** take notes). See ***Interview 2: Farmer-Level Interview Protocol section***.
8. Consult your *Checklist* to ensure that you have completed all components necessary for each farmer.
9. Repeat until you have completed your interview goal (5 or 10 farmers per person)
10. If the farmer is interested, develop a management plan/scenario for the farmer that includes adding one or more conservation methods that are targeted to their landscape and operation.
11. Conduct individual/group discussions about farm scenarios to discuss facilitators and barriers to adoption of practices.

III. Interview 1 and 2 Checklist

Farmer ID______________________ Extension Ed.___________________

- ○ Recruit farmer
- ○ Set time for first meeting with farmer
- ○ Bring *Interview 1: Farm-Level Data Collection* worksheet with you to meet with the farmer and conduct the interview about their farm and specific fields.
- ○ Upload data into the online data sheet that is found at the sustainablecorn.org website.
- ○ Set up second interview time with farmer.
- ○ Bring recording device, the last two pages of the Conservation Questions in the Data Collection worksheet (filled out at the last interview) and bring *Interview 2: Farmer-Level Interview Protocol* with you
- ○ Conduct semi-structured interview with the farmer
- ○ Collect receipt(s) and alert farmer that they will receive two payments, one in each calendar year from Iowa State University (total will be $100 or two installments of $50)
- ○ Send thank you email or follow-up with phone call to farmer.
- ○ Place digital files in the shared Google Drive here and typed notes to Gabrielle Roesch at geroesch@iastate.edu. Be sure to email Gabrielle when you have posted the audio file.

SECTION A. Interview 1: *Farm-Level Data Collection*

[**Sample Script**] As a farmer in the [region X], you have been selected to participate in a study we are conducting. I want to begin by telling you that your participation in this study is voluntary, and if we come to any question that you do not wish to answer you can just tell me to go on to the next question . You may opt out of the study at any time. Your individual responses will remain confidential and any information reported as a result of this research will maintain your anonymity. This study consists of two in-person interviews. Today I would like to gather some information on the management of two fields; I expect this process to take about an hour. Then, whenever it is convenient but as soon as possible, I would like to meet with you again for a longer interview, which should take between 1-1.5 hours. We recognize that your time is valuable, and therefore, we are offering a $100 honorarium for participants that complete both interviews.

Our study is part of a larger multi-state project that is interested in ensuring that corn production is economically and ecologically sustainable into the future.

First, I would like to collect some [basic] information on your farm practices for [two] fields [choose total of two fields, one good field and one marginal]. I will take this information here today and use it to model some agronomic and environmental outputs associated with this field—by this I mean things like crop yield, nutrient budgets, and soil loss.

- ***Fill out Data Collection Sheet***

Variable scripting:

I would like to meet with you again whenever it is convenient but as soon as possible to have a broader conversation about your farm management and other issues that relate to your agricultural enterprise. We can arrange a time now, or I can contact you in a week or so to schedule a time.

Some other things that we would like to look at with your interest and voluntary participation:

- ❖ Development of field-level scenarios that will help us to characterize some of the environmental outputs from your current operation along with some information that might include variations to your current management that might include additional conservation tools.
- ❖ This information will be presented down the road in a setting that works for you.
- ❖ We would also be interested in working with a group of farmers in the area to discuss watershed scenarios that would help us explore the impacts of a variety of practices.

Again, I want to thank you for your willingness to participate in this research project. Your voice will influence researchers and policymakers who are very interested in understanding farmers' perspectives throughout the Corn Belt.

SECTION B: *Farmer-Level Interview Protocol*

Prior to arriving for an interview, do the following:

a. Make list of the conservation practices this farmer uses on his/her fields for which data were gathered or bring their Data Collection worksheet with you.
b. Print Google Earth map of their fields to aid in the discussion about management practices.

Part I: Icebreakers

1. Can you tell me a little bit about the history of your farm and your farming operation?

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____
____

Part II: Conservation Practices

Revisit discussion from the end of the data collection interview… "Last time we talked about your overall conservation practices and some of your future goals with regards to specific fields. I would like to start with a discussion about the specific practices that you use on the fields that we talked about last time, how you first got started with them and how your use of these practices may have changed over time."

1. Nutrient management refers to ways in which the amount, form, placement, and timing of the application of nutrients to crop plants is controlled.

a. Could you describe your nutrient management system in detail for each of the fields we discussed last time?

____

____

____

b. What are your main motivations for managing nutrients the way you do?

____

____

Prompts:
1) What kinds of fertilizers are used?
2) When are fertilizers typically applied?
3) How are application rates determined?
4) What is done to minimize nutrient loss?

2. Tillage:

I would like to ask a few questions about your tillage methods used on these two fields.

a. When did you start using [whatever the tillage practice is] on these field(s), and what were your main motivations for starting?

____

____

____

b. What are the primary benefits of your tillage approach? [financial, soil health, off-farm environmental?]

____

____

____

c. Are there challenges associated with using this tillage approach?

____

____

____

d. Where do you get information about tillage methods?

____

____

____

Prompts:
1. What factors have determined their choice of tillage methods? (i.e., economic, soil health, erosion).

3. Cover crops

IF they use cover crops on either of the fields:

a. When did you start using cover crops, and what were your main motivations for starting?

____

____

____

b. What are the main species you utilize as cover crops?

____

____

____

c. What are the primary benefits of your cover crops approach? [financial, soil health, off-farm environmental?]

____

____

____

d. Are there any challenges associated with using cover crops on these fields?

____

____

____

e. Where do you get information on cover crops*?*

____

____

____

IF they do not use cover crops on either of the fields:

f. Have you ever used cover crops? [If not, ask why they have not tried them. If yes, ask what their experience was, and why they no longer use them.]

____

____

____

g. Would you consider using cover crops in the future? If so, under what conditions would you be willing to? [Cost-share, custom planting, government support etc?]

____

____

____

Prompts:

1. What do they think about the potential uses of specific cover crops and how this might enhance/detract from their operation? (e.g. do they see other market or forage benefits of a specific crop)

Note: Remember to reference back to the conservation practice data that you collected at the end of Interview 1.

4. Other practices _________________ (Pick *one or two* major/unique methods used on their fields or on their entire farm)

a. When did you start using X practice, and what were your main motivations for starting?

____

____

____

b. What are the primary benefits of using X practice? [financial, soil health, off-farm environmental?]

____

____

____

c. Are there challenges associated with using this method?

____

____

____

5. Other Conservation Methods:

a. Have you ever heard of drainage water management? If so, what do you think about it?

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b. Have you ever heard of nitrogen sensors? If so, what do you think about them?

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____

____

c. What, if any, practices do you implement differently on land you own as opposed to land you rent?

____

____

____

d. How satisfied are you with the overall level of soil and water conservation practices and strategies that are in place on the land you farm?

e. Are there any conservation challenges that you would like to take care of (i.e., gullies) but have not been able to yet? If so, what are the main barriers?

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____

Part III: Weather Variability

1. Over the past five years or so, what, if any, extreme weather have you experienced that has adversely affected your farm operation? [*If any*, ask follow-on questions about impacts of each]

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____

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2. Have these weather events changed your management practices at all? If so, how?

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3. There have been a lot of discussions lately about global climate change and its potential impacts on agriculture.

a. What are *your* opinions about climate change?

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____

____

b. What concerns, if any, do you have about potential impacts on your farm operation?

____

____

____

4. **IF FARMER thinks that climate change is occurring ask**: What do you think are the causes of climate change and who do you think is responsible for addressing the challenges associated with it?

____

____

____

a. What sources of information about climate and weather variability do you trust the most? [**Ask** whether they talk to other farmers and others about climate change]

____

____

____

5. **IF Farmer doesn't think that human or naturally caused climate change is happening AT ALL then ask**: What types of information, conversations, or other resources have shaped your current thoughts on climate change?

____

____

____

Part IV: Trusted Sources of Information

1. Who do you look to for information on conservation management practices? [**Explore** specifically for whom they trust when it comes to these issues]?

____

____

____

   a. Can you give me a sense of what these particular organizations/agencies do specifically that make you more willing to take their advice or technical expertise?

____

____

____

2. What can extension, government, or the private sector do to assist further development of conservation practices on your farm? [**Explore** each entity]

____

____

____

3. What types of programs or policies do you think might assist you participating in more conservation programs or implementing new/different management practices?

____

____

____

Part V: Resiliency

1. Can you describe what long-term, on-farm sustainability means to you?

____

____

____

2. Let's think about your marginal field right now, or other marginal areas on your whole farm, and consider other uses that might be of value or interest to you.

Would you ever consider changing your current cropping system on this field and if so, what are the types of things you have considered doing with this land?

____

____

____

a. Would you ever consider growing other row crops, fruits/vegetables, or converting marginal cropland to pasture for livestock?

b. What about adding woodlots, incorporating agroforestry or other land uses, including wetlands or prairie restoration?

3. As you think about *your* business and the lifestyle of farming, what is it that you most want researchers and perhaps government agencies to understand about the long-term goals you have for your farming operation?

Final Follow-Up (Keep Recorder Going)

1. As we wrap up do you have any questions for me?
2. Going forward with this project over the next few years, do you have any specific requests for additional information, with regards to climate/weather variability or conservation management practices, that you would like more resources on for coming meetings/workshops?

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APPENDIX B
CSCAP INSTITUTIONAL REVIEW BOARD FORM #1

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 10/15/2014

To: Dr. John Tyndall
238 Science II

From: Office for Responsible Research

Title: Sustainable Corn Production: Farm-Level Scenario Analysis and Economic Assessment

IRB ID: 12-473

Study Review Date: 10/15/2014

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**

- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

Please be aware that **approval from other entities may also be needed.** For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.**

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.

Assigned IRB ID: **12-473**

INSTITUTIONAL REVIEW BOARD (IRB)
Amendment for Personnel Changes

RECEIVED

OCT 15 2014

By IRB

Title of Project: Sustainable Corn Production: Farm-Level Scenario Analysis and Economic Assessment

Principal Investigator (PI): **John Tyndall**		Degrees: PhD
University ID: **11297430425**	Phone: 515.294.4912	Email Address: jtyndall@iastate.edu

FOR STUDENT PROJECTS (*Required when the principal investigator is a student*)		
Name of Major Professor/Supervising Faculty:		
University ID:	Phone:	Email Address: @iastate.edu

Changes in Key Personnel:

Key personnel includes any individuals who will have contact with the participants or the participants' data (e.g., interviewers, transcribers, coders, etc.). This information is intended to inform the committee of the training and background related to the specific procedures that each person will perform on the project. For more information, please see Human Subjects - Persons Required to Obtain IRB Training. Personnel who will have contact with human blood, specimens, or other biohazardous materials must also complete Bloodborne Pathogens Training. *If the principal investigator has or will change, a complete new IRB application is required.*

1. List any individuals to be removed from the study staff:

2. Complete the following table to list any new key personnel:

NAME	Interpersonal contact or communication with subjects, or access to private identifiable data?	Involved in the consent process?	Contact with human blood, specimens, or other biohazardous materials?	Other Roles in Research	Qualifications (i.e., special training, degrees, certifications, coursework, etc.)	Human Subjects Training Date
✓Jean McGuire	☐	☐	☐	Data analysis	MS, Sociology	5-7-08
✓Adam Wilke	☐	☐	☐	Data analysis	MS, Sociology	08-29-11
✓Rebecca Clay	☐	☐	☐	Data analysis		4-21-14
✓Syed Maaz Gardezi	☐	☐	☐	Data analysis	MS, NRM	9-14-14
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			

	☐	☐	☐			

☐ Yes	☒ No	**3. Does your study include children (persons under age 18) as research subjects?**

If ***Yes***, please read and respond to the following:

ISU policy requires that background checks be completed for all researchers and key personnel who will have any contact with children involved in this research project. Details regarding this policy can be found here. **Principal Investigators and faculty supervisors are responsible** for ensuring that background checks are completed BEFORE researchers or key personnel may have any contact with children. Records documenting completion of the background checks must be kept with other research records (e.g., signed informed consent documents, approved IRB applications, etc.) and may be requested during any audits or Post-Approval Monitoring of your study.

☒ Agreed **3.a. Please check here to indicate that you have read this information and agree that you will comply with these requirements.**

FOR IRB USE ONLY	☑ All human subjects training requirements have been met.
IRB Reviewer's Signature [redacted]	*Date* 10/15/14

APPENDIX C

U2U INSTITUTIONAL REVIEW BOARD FORM #2

IRB ID:

INSTITUTIONAL REVIEW BOARD (IRB)

Application for Approval of Research Involving Humans

Title of Project: Useful to Usbale (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers

Principal Investigator (PI): **Lois Wright Morton**			Degrees: 0592PhD
University ID:	Phone: 515-294-2643	Email Address: lwmorton@iastate.edu	
Correspondence Address: 317C East Hall Ames, Iowa 5011-1070			
Department: Sociology		College/Center/Institute: Agriculture and Life Sciences	
PI Level: ☒ Tenured, Tenure-Eligible, & NTER Faculty ☐ Adjunct/Affiliate Faculty ☐ Collaborator Faculty ☐ Emeritus Faculty ☐ Visiting Faculty/Scientist ☐ Senior Lecturer/Clinician ☐ Lecturer/Clinician, Ph.D. or DVM ☐ P&S Employee, P37 & above ☐ Extension to Families/Youth Specialist ☐ Field Specialist III ☐ Postdoctoral Associate ☐ Graduate/Undergrad Student ☐ Other (specify:)			

FOR STUDENT PROJECTS (*Required when the principal investigator is a student*)				
Name of Major Professor/Supervising Faculty:				
University ID:	Phone:	Email Address: @iastate.edu		
Campus Address:		Department:		
Type of Project (check all that apply):	☐ Thesis/Dissertation	☐ Class Project	☐ Other (specify:)	

Alternate Contact Person: Jean McGuire	Email Address: jmcguire@iastate.edu
Correspondence Address: 317B East Hall Ames, Iowa 5011-1070	Phone: 515-294-3383

ASSURANCE

- I certify that the information provided in this application is complete and accurate and consistent with any proposal(s) submitted to external funding agencies. Misrepresentation of the research described in this or any other IRB application may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.
- I agree to provide proper surveillance of this project to ensure that the rights and welfare of the human subjects are protected. I will report any problems to the IRB.
- I agree that modifications to the originally approved project will not take place without prior review and approval by the IRB.
- I agree that the research will not take place without the receipt of permission from any cooperating institutions, when applicable.
- I agree to obtain approval from other appropriate committees as needed for this project, such as the IACUC (if the research includes animals), the IBC (for research involving biohazards), the Radiation Safety Committee (for research involving x-rays or other radiation producing devices or procedures), etc.
- I agree that all activities will be performed in accordance with all applicable federal, state, local, and Iowa State University policies.

____

Signature of Principal Investigator Date

____

Signature of Major Professor/Supervising Faculty Date
(*Required when the principal investigator is a student*)

- I have reviewed this application and determined that departmental requirements are met, the investigator(s) has/have adequate resources to conduct the research, and the research design is scientifically sound and has scientific merit.

____

Signature of Department Chair Date

For IRB Use Only	Full Committee Review: ☐	Review Date:
	EXPEDITED per 45 CFR 46.110(b): Category Letter	Approval/Determination Date:
Approval Not Required: ☐		Approval Expiration Date:
Not Research: ☐	EXEMPT per 45 CFR 46.101(b):	
No Human Subjects: ☐	Not Approved: ☐	Risk: Minimal ☐ More than Minimal ☐
IRB Reviewer's Signature		

Research Involving Humans Study Information

Please provide answers to all questions, except as specified. Incomplete forms will be returned without review.

Part A: Key Personnel

List all members and relevant qualifications of the project personnel. Key personnel includes the principal investigator, co-principal investigators, supervising faculty member, and any other individuals who will have contact with the participants or the participants' data (e.g., interviewers, transcribers, coders, etc.). This information is intended to inform the committee of the training and background related to the specific procedures that each person will perform on the project. For more information, please see Human Subjects - Persons Required to Obtain IRB Training.

NAME	Interpersonal contact or communication with subjects, or access to private identifiable data?	Involved in the consent process?	Contact with human blood, specimens, or other biohazardous materials?	Other Roles in Research	Qualifications (i.e., special training, degrees, certifications, coursework, etc.)	Human Subjects Training Date
Lois Wright Morton	☒	☒	☐		**Professor PhD**	**10/09/2000**
Jean McGuire	☒	☒	☐		**Doctoral Student**	**05/07/2008**
Adam Wilke	☒	☒	☐		**Masters Student**	**08/29/2011**
	☐	☐	☐			
	☐	☐	☐			
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	☐	☐	☐			
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	☐	☐	☐			
	☐	☐	☐			
	☐	☐	☐			

Please complete additional pages of key personnel as necessary.

Part B: Funding Information

☒ **Yes** ☐ **No**	1.	Is the project federally funded? If ***Yes***, please provide the complete name(s) of the source(s); please do not use acronyms. **Please attach a complete copy of the federal grant proposal from which the study is funded.**
		United States Department of Agriculture -- National Institute of Food and Agriculture (Appendix H)

Part C: General Overview

2. **Study Objectives –** Briefly explain in language understandable to a layperson the purpose and specific aim(s) of the study.

The goal of the Useful to Usable (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers project is to improve the resilience and profitability of farms in the 12 state North Central Region (See Appendix A) amid variable climate change through the development and dissemination of decision support tools. Social scientists representing 9 of the 12 states in the region, will address these critical issues through these five broad objectives:
1. Use existing data to develop a knowledge base of potential biophysical and economic impacts related to climate changes and consider the relative risks they pose.
2. Understand how producers make decisions under uncertain climate projections, what type of information they need to make better decisions, and what are effective methods for disseminating usable knowledge to them and larger agricultural networks.
3. Develop tools, training materials, and implementation approaches that lead to more effective decision-making and adoption of practices associated with farms resilient to climate variability.
4. Evaluate the effectiveness of the tools, training materials, and implementation approaches for corn/soybean producers in four pilot states (Indiana, Iowa, Nebraska, and Michigan).
5. Broadly disseminate validated training materials, tools, and extension programs to ensure increased usefulness and usability of climate information.

More specifically the Human Dimension portion of this project will explore the use and value of climate information and projections among cereal crop producers in the North Central Region by examining the role of networks and iterative modes of science and decision making and working with those stakeholder to help them incorporate climate-information driven decision support tools into their farming decision process. This "coproduction" of science is increasingly being called for by groups such as the National Academy of Scientists (NRC, 2009, 2010). We use the term producers to mean people growing corn/soybeans on their own or rented land. We use the term advisors to mean people who work with producers and help them make decisions including bankers, crop advisors and others; a special type of advisor group is extension.

3. **Benefits to Society and Participants –** Explain in language understandable to a layperson how the information gained in this study will advance knowledge, and/or serve the good of society.

Agricultural crops contribute about $150 billion annually to the U.S. economy, most of which comes from the intensely cultivated Midwest. This level of production relies on favorable temperatures and appropriate

precipitation patterns. Variation in either, including fewer frosts and earlier warm days for temperature and increased occurrences of extreme variability in rainfall, limit season-to-season predictability and lessen the ability of producers to maintain viable farm operations. This presents significant challenges to the corn economy in the North Central Region where farmers grew approximately 88% of U.S. corn in 2009. The potential for this project to lead to long-term improvement and sustainability of cereal crop production in the North Central Region is very high as climate change and climate variability greatly impact corn production. The Region's long-term economic viability requires better information predictive resources regarding climate.
4. Describe the direct benefits to research participants; if there are no direct benefits to participants, indicate that. Note: Monetary compensation cannot be considered a benefit to participants.
At the end of the project the participants will have access to better tools and mechanisms to inform corn production decisions with critical economic impact under current conditions of climate change.

Part D: Anticipated Enrollment

Estimated number of participants to be enrolled in the study Total: 24,000 Males: 23,000 Females: 2,000	
Check below if you intend to include persons from the following groups: ☐ Minors (Under 18) Age Range of Minors: ☐ Pregnant Women/Fetuses ☐ Cognitively Impaired ☐ Prisoners	Check below if this project includes: ☒ Adults, non-students ☐ Minor ISU students ☐ ISU students 18 and older ☐ Other (explain)
List estimated percent of the anticipated enrollment that will be minorities *if known*:	
American Indian: 100	Alaskan Native:
Asian or Pacific Islander:	Black or African American:
Latino or Hispanic:	

Part E: Participant Selection and Recruitment

Please use additional space as necessary to adequately answer each question.

5. Explain the procedures and rationale for selecting participants, including the inclusion and exclusion criteria (e.g., where will names come from, what persons will be included or excluded and why, etc.).
Three groups of participants will be involved in this project. **The first group is state climatologists from the 12 states in the North Central Region. This group is limited to those individuals who hold the title of state climatologist for their state and other climatologists from land grant universities who are serving as principal investigators on this project.** **The second group is corn producers in the North Central Region who will participate in a survey that is being issued in conjunction with the Climate Change, Mitigation, and Adaptation in Corn-Base Cropping System project (Appendix B). The details on how those individuals were chosen can be found in the approved Exempt Study**

Review submitted by J. Gordon Arbuckle Id 10-599. A copy of that approved form has been attached to this application (Appendix C). In addition, focus groups of corn producers will be held in Iowa in 2013. Focus group member selection procedures and questions will be developed and submitted to Iowa State University IRB at a later time and are not attached to this application.

The last group that will be studied are advisors to corn producers. This group includes extension staff from Iowa State University, Michigan State University, University of Nebraska-Lincoln and Purdue. Other members of this group include crop advisers, insurance agents, equipment dealers, financial advisers, bankers and others in Indiana, Iowa, Michigan and Nebraska. The selection criteria is quite broad and includes any individual or groups of individuals who advise corn producers in the North Central Region. Focus group questions for the corn producer advisers will be developed and submitted to Iowa State University IRB at a later time and are not attached to this application.

6. Describe the procedures for contacting participants (e.g., letter, email, flyer, advertisements, phone call, etc.). Attach copies of any letters, scripts, flyers, or advertisements that will be used.

The state climatologists will be contacted directly by e-mail and telephone in the Spring 2012 for in-person interviews. Procedures and protocol are attached to this application and include the consent form, mini survey and interview prompts.

Contact procedures for corn producers in the North Central Region who will participate in the survey being performed by social scientists on this project are available in the approved Iowa State University Exempt Study Review forms submitted by J. Gordon Arbuckle Id 10-599. A copy of that approved form has been attached to this application as Appendix B. The survey instrument is attached to this application as Appendix C. In addition, focus groups of Iowa corn producers will be held in 2013. Focus group selection contact procedures will be developed and submitted to Iowa State University IRB at a later time and are not attached to this application.

Contact protocol for the advisers of North Central Region corn producers will include e-mails for the survey portion and phone calls for the focus group portion of the project. Documents and procedures for corn producer adviser survey and focus groups will be developed and submitted for review and approval once they are complete and are not attached to this application.

Part F: Research Plan

Include sufficient detail for IRB review of this project independent of any other documents.

☒ **Yes**	☐ **No**	7. Does this project involve using existing data or records? If ***Yes***, describe the data/records in the Research Plan, question 9.
☒ **Yes**	☐ **No**	8. Does this project involve secondary analysis? If ***Yes***, describe the source of the data in the Research Plan, question 9**.**

9. **Research Plan –** The information needed here is similar to that in the “methods” or “procedures” sections of a

research proposal—it should describe the flow of events that will occur during your interactions with subjects. Please describe in detail your plans for collecting data from participants, including **all** procedures, tasks, or interventions participants will be asked to complete during the research (e.g., random assignment, any conditions or treatment groups into which participants will be divided, mail survey or interview procedures, sensors to be worn, amount of blood drawn, etc.). This information is intended to inform the committee of the procedures used in the study and their potential risk. **Please do not respond with "see attached" or "not applicable."**
Interviews with state climatologists will be performed in Spring 2012. Those interviews will be recorded and transcribed. Interviews will them be coded for themes and analyzed amongst the total group of interviews for emergent themes. The interview questions are provided in Appendix D. Climatologists will also complete a brief survey, which will be analyzed quantitatively (Appendix E). **Two surveys will be performed in this project. The first is a survey of corn producers in the North Central Region. This survey is being done with the Climate Change, Mitigation, and Adaptation in Corn-Based Cropping Systems (CSCAP). Dr. J Gordon Arbuckle has already applied for and received approval to exempt this particular study through the Iowa State University Review Board. The IRB ID is 10-599. A copy of this survey is attached (Appendix C) Following analysis of the survey, focus groups with corn producers will be held throughout the North Central Region. The procedures and questions for those focus groups will be developed and submitted to IRB in 2013 and are not attached to this application.** **The second survey will be e-mailed to those who advise corn producers. Most of the questions will be identical to or slightly modified the questions in the corn producers. A draft of that survey (Appendix F) is attached to this application. This survey will cover only the states of Indiana, Iowa, Michigan and Nebraska. The ISU team will be responsible for dispersing and collecting the data for Iowa. Following analysis of the advisor survey, focus groups will be held to add qualitative explanations to the quantitative data collected in the survey. Questions for those focus groups will be submitted to the IRB upon development and are not attached to this application.**

10. For studies involving deception or where information is intentionally withheld from participants, such as the full purpose of the study, please explain how persons will be deceived or what information will be withheld. Additionally, a waiver of the applicable elements of consent will be needed. Please complete the Waiver of Elements of Consent form. If this question is not applicable, please type N/A in the response cell.
Not applicable

☐ **Yes**	☒ **No**	11. Does your project require the use of a health care provider's records concerning past, present, or future physical, dental, or mental health information about a subject? The Health Insurance Portability and Accountability Act established the conditions under which protected health information may be used or disclosed for research purposes. If your project will involve the use of any past or present clinical information about someone, or if you will add clinical information to someone's treatment record (electronic or paper) during the study, you must complete and submit the Application for Use of Protected Health Information.

☐ **Yes**	☒ **No**	12. Does this project involve an investigational new drug (IND)? Number:
☐ **Yes**	☒ **No**	13. Does this project involve an investigational device exemption (IDE)? Number:
☐ **Yes**	☒ **No**	14. Does this project involve DEXA/CT scans or X-rays?

☐ **Yes**	☒ **No**	15. Does this project involve pathology or diagnostic specimens? If ***Yes***, indicate whether specimens will be collected prospectively and/or already exist "on the shelf" at the time of submission of this review form. If prospective, describe specimen procurement procedures, indicate whether any additional medical information about the subject is being gathered, and whether specimens are linked at any time by code number to the participant's identity. If this question is not applicable, please type N/A in the response cell.

Part G: Consent Process

A copy of any translated informed consent documents and an English version should be submitted with the application. Provide the name of the individual who translated the consent documents and their qualifications for translating consent documents below.

If the consent process does not include documented (signed) consent, please request a Waiver of Documentation of Consent. If any information about the study is intentionally withheld or misleading (i.e., deception is used), a Waiver of Elements of Consent must be requested. Links to the forms for requesting waivers are also available at the IRB website.

16. Describe the consent process for adult participants (those who are age 18 and older). Include information about who will obtain consent from participants; how/when consent will be obtained in relation to actual data gathering; whether someone other than the subject will provide consent (e.g., a legally authorized representative); etc.

Consent will be obtained prior to the interviews with the state climatologists. The consent form is included as Appendix G.

Consent will be obtained for the survey of the North Central Region corn producers at the beginning of the survey. This process was approved in ISU IRB 10-599 in Appendix C of the application. Once the focus group protocol is developed a specific consent form will be developed and submitted for review to Iowa State University IRB at a later time and are not attached to this application.

Consent will be obtained for the survey of the advisers of North Central Region corn producers at the beginning of the e-mail survey. The specific language of that consent is being developed and will be submitted for review to Iowa State University IRB at a later time and is not attached to this application. The focus groups planned for this group, a specific consent form will be developed and submitted for review to Iowa State University IRB at a later time and are not attached to this application.

17. If your study involves minor children, please explain how parental consent will be obtained prior to enrollment of the minor(s).

No minors involved

18. Please explain how assent will be obtained from minors (younger than 18 years of age) prior to their enrollment.

Also, please explain if the assent process will be documented (*e.g., a simplified version of the consent form, combined with the parental informed consent document).* According to the federal regulations **assent** "…means a child's affirmative agreement to participate in research. Mere failure to object should not, absent affirmative agreement, be construed as assent."

Part H: Data Analysis

19. Describe how the data will be analyzed (*e.g., statistical methodology, statistical evaluation, statistical measures used to evaluate results*).
Quantitative data (surveys) will be analyzed using statistical software programs such as SAS, SPSS, and MPlus. Qualitative data (interviews and focus groups) will be analyzed using NVIVO software and by hand coding by Dr. Morton or her graduate students. No personally identifiable information will be present in either the quantitative or qualitative analysis.

Part I: Risks

The concept of risk goes beyond physical risk and includes risks to participants' dignity and self-respect as well as psychological, emotional, legal, social or financial risks.

☐ **Yes**	☒ **No**	20. Is the ***probability*** of the harm or discomfort anticipated in the proposed research greater than that encountered ordinarily in daily life or during the performance of routine physical or psychological examinations or tests?
☐ **Yes**	☒ **No**	21. Is the ***magnitude*** of the harm or discomfort greater than that encountered ordinarily in daily life or during the performance of routine physical or psychological examinations or tests?

22. Describe any foreseeable risks or discomforts to the participants and how they will be minimized and precautions taken. **Do *not* respond with N/A**. If you believe that there will not be risk or discomfort to participants, *you must explain why*.
There will be no risk or discomfort to the participants because no personally identifiable information will be released and their identities will not be connected to any of their statements or information they provided.

23. If this study involves vulnerable populations, including minors, pregnant women, prisoners, the cognitively impaired, or those educationally or economically disadvantaged, what additional protections will be provided to minimize risks?

Not applicable

Part J: Compensation

☐ **Yes**	☒ **No**	24. Will participants receive compensation (including course credit/extra credit) for their participation? If ***Yes***, please describe compensation plans below. **Note:** Do not make the payment an inducement—only a compensation for expenses and inconvenience. If a person is to receive money or another token of appreciation for their participation, explain when it will be given and any conditions of full or partial payment. (For example, volunteers will receive $5.00 for each of the five visits in the study or a total of $25.00 if they complete the study. If a participant withdraws from participation, he/she will receive $5.00 for each of the visits completed.) It is considered undue influence to make completion of the study the basis for compensation.

Part K: Confidentiality

25. Describe below the methods that will be used to ensure the confidentiality of data obtained. For example, describe who will have access to the data, where the data will be stored, security measures for web-based surveys and computer storage, how long data or specimens will be retained, what (if any) identifiers will be retained, etc.
Records identifying participants will be kept confidential to the extent permitted by applicable law and regulations and will not be made publicly available. However, federal government regulatory agencies (USDA as project grantor) and the Iowa State University Institutional Review Board may inspect and /or copy records for quality assurance and data analysis. These records may include private information. To ensure confidentiality to the extent permitted by law, the following measures will be taken: Interviewed subjects will be assigned a unique code that will be used on forms instead of their names. Study records will be available to the research team -- Dr. Lois Wright Morton and trained graduate students. Tape recordings of interviews and focus groups will be locked in Dr. Morton's office and destroyed two years after completion of the project (April 1, 2018). If the results are published, all personally identifiable information will be excluded.

Part L: Registry Projects

☐ **Yes**	☒ **No**	26. Does this project establish a registry? If ***Yes***, please provide the registry name below. **Note:** To be considered a registry: (1) the individuals must have a common condition or demonstrate common responses to questions; (2) the individuals in the registry might be contacted in the future; and (3) the names/data of the individuals in the

registry might be used by investigators other than the one maintaining the registry.

Checklist for Attachments

Listed below are the types of documents that should be submitted for IRB review. Please check **and attach** the documents that are applicable for your study:

☒ Federal grant application (only for federally funded research)
☒ A copy of the informed consent document or letter of introduction containing the elements of consent
☒ A copy of the forms requesting waivers of elements of consent or documentation of consent, where applicable
☒ A copy of the assent form if minors will be enrolled
☒ Data-gathering instruments (including surveys)
☒ Recruitment fliers, phone scripts, or any other documents or materials participants will see or hear

The original signed copy of the application form and one set of accompanying materials should be submitted for review.

ENVIRONMENTAL HEALTH AND SAFETY INFORMATION

PART M: HUMAN CELL LINES

☐ **Yes** ☒ **No**	1. Does this project involve human cell or tissue cultures (primary OR immortalized cell lines/strains) that have been documented to be free of bloodborne pathogens? If the answer is ***Yes***, please answer question A below and attach copies of the documentation.

A. Please list the specific cell lines/strains to be used, their source and description of use.

CELL LINE	SOURCE	DESCRIPTION OF USE

B. Please refer to the ISU *Bloodborne Pathogens Manual*, which contains the requirements of the OSHA Bloodborne Pathogens Standard. Please list the specific precautions to be followed for this project below (e.g., retractable needles used for blood draws):

Anyone working with human cell lines/strains that have not been documented to be free of bloodborne pathogens is required to have Bloodborne Pathogen Training annually. Current Bloodborne Pathogen Training dates must be listed in Section I for all Key Personnel. Please contact Environmental Health and Safety (294-5359) if you need to sign up for training and/or to get a copy of the Bloodborne Pathogens Manual.

PART N: HUMAN BLOOD COMPONENTS, BODY FLUIDS OR TISSUES

☐ **Yes** ☒ **No**	2. Does this project involve human blood components, body fluids or tissues? If ***Yes***, please answer all of the questions in the "Human Blood Components, Body Fluids or Tissues" section.

A. Please list the specific human substances used, their source, amount and description of use.

SUBSTANCE	SOURCE	AMOUNT	DESCRIPTION OF USE
E.g., Blood	*Normal healthy volunteers*	*2 ml*	*Approximate quantity, assays to be done.*

B. Please refer to the ISU *Bloodborne Pathogens Manual*, which contains the requirements of the OSHA Bloodborne Pathogens Standard. Specific sections to be followed for this project are:

Anyone working with human blood components, body fluids or tissues is required to have Bloodborne Pathogen Training annually. Current Bloodborne Pathogen Training dates must be listed in Section I for all Key Personnel. Please contact Environmental Health and Safety (294-5359) if you need to sign up for training and/or to get a copy of the Bloodborne Pathogens Manual.

APPENDIX D
CSCAP FARMER QUALITATIVE ANALYSIS CODEBOOK

CSCAP Farmer Interview
Qualitative Analysis Codebook
Adam Wilke

Coding Instructions for CSCAP Farmer Interviews

Unit of Analysis

Responses to interview questions from typed transcript of 159 farmer interviews in the North Central Region of the United States. Interviews conducted by regional extension educators and social science graduate student. Question content seeks to understand current agricultural management practices, perceptions of weather and climate, and barriers and facilitators of conservation practice adoption.

Procedure

Read transcript page to page. Audio recordings of the transcript may also be important to detect hesitance or emphasis in word choice.

Directions

Count the number of references to a conceptual idea (listed below) in each page. Highlight these references in the transcript. For each data, enter the number of references to the conceptual idea. Complete summary of dominant themes in transcript.

Theoretical framework

Decision making = f(temporal-past [historical; recent]; spatial variation; soil type and condition; rainfall/irrigated; precipitation; temperature; extreme events; control demographics + e)

Coding categories

(1) Time
(2) Social
(3) Economic
(4) Geographic/spatial
(5) Climate
(6) Soil
(7) Water
(8) Adaptive management responses
(9) View of climate changes on the land

Measures (indicators referenced in transcript)

(1) Time
    1. Historical and recent past (H)
        i. Personally experienced past events (H1)
        ii. Narratives of past events (H2)
    2. Present – current, now (P)
    3. Future (F)

(2) Social
    1. H12 * family, H12 * friends, H12 * agency (e.g. university, NRCS, USDA, watershed districts), H12 * NGO (e.g. Corn Growers Association, Practical Farmers of Iowa)
    2. P * family, P * friends, P * agency, P * NGO
    3. Informal networks
    4. Formal networks
    5. Social spaces (church, coffee shop, convenience story, county roads, etc.)
        i. Geography * social space

(3) Economic
    1. H * crop prices, H * farm financial viability, H * crop insurance
    2. P * crop prices, P * farm financial viability, P * crop insurance

(4) Geographic/spatial
    1. H * space
    2. R * space

(5) Climate
    1. H * precipitation, H * temperature
    2. R * precipitation, R * temperature

(6) Soil

1. H * soil
2. R * soil

(7) Water
1. H * water availability, timing, and quality
2. R * water availability, timing, and quality

(8) Adaptive management responses
1. Tiling, tillage, cover crops, crop rotation, irrigation, fertilizer, different crop choice, soil conservation, early and late planting, purchase insurance, sell/buy land, equipment, change seed variety.
2. Reasons for no adaptation – lack of information, lack of money, shortage of labor, shortage of equipment, don't need to (beliefs)

(9) View of changes on the land (code 1-10), spectrum from:
1. Steady state, status quo, no change (1)
2. Not clear, ambiguous (5)
3. Dynamic, always changing (10)