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Soil as Social-Ecological Feedback: Examining the "Ethic" of Soil Stewardship among Corn Belt Farmers

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Abstract

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Disciplines

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Soil as Social-Ecological Feedback: Examining the "Ethic" of Soil Stewardship among Corn Belt Farmers*

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In this article we examine in-depth interviews with farmers ($n = 159$) from nine Corn Belt states. Using a grounded theory approach, we identified a "soil stewardship ethic," which exemplifies how farmers are talking about building the long-term sustainability of their farm operation in light of more variable and extreme weather events. Findings suggest that farmers' shifting relationship with their soil resources may act as a kind of social-ecological feedback that enables farmers to implement adaptive strategies (e.g., no-till farming, cover crops) that build resilience in the face of increasingly variable and extreme weather, in contrast to emphasizing short-term adjustments to production that may lead to greater vulnerability over time. The development of a soil stewardship ethic may help farmers to resolve the problem of an apparent trade-off between short-term productivist goals and long-term conservation goals and in doing so may point toward an emergent aspect of a conservationist identity. Focusing on the message of managing soil health to mitigate weather-related risks and preserving soil resources for future generations may provide a pragmatic solution for helping farmers to reorient farm production practices, which would have soil building and soil saving at their center.

Introduction

Globally, there is growing awareness that preserving soil resources and enhancing soil quality will help to reduce agricultural systems' social and ecological vulnerability, particularly in light of anthropogenic climate change (Cruse et al. 2012; Lal 2014; Melillo, Richmond, and Yohe 2014; Morton et al. 2015). To address the degradation of soil resources,

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global agricultural conservation efforts are emphasizing soil health and erosion prevention as a way to build greater resilience in agriculturally productive regions. These efforts are evidenced in the Food and Agricultural Organization's commitment to the work of the Global Soil Partnership as well as the development of the nascent Intergovernmental Technical Panel on Soils (see Montanarella 2015). Since 2012, soil health has been actively promoted in the United States through an education and outreach campaign sponsored by the U.S. Department of Agriculture's Natural Resources Conservation Service's Soil Health Initiative (NRCS 2015). This Soil Health Initiative emphasizes improvements in soil health through the increased use and adoption of no-till farming and cover crops, particularly in combination, to meet both conservation and production goals.

Managing for healthy soils often requires the adoption and continued use of best management practices, such as no-till farming and cover crops (Lehman et al. 2015), which have environmental and economic benefits. Soil health, also referred to as soil quality, is defined as "the fitness of the soil to carry out biological production and environmental protection functions within specified land use, landscape, and climate boundaries" (Harris, Karlen, and Mulla 1996:61). Harris et al. (1996) suggest that soil health is often the preferred terminology used by farmers while scientists typically refer to soil quality; however, for our purposes here, we will use these terms interchangeably.

Healthy soils are built over long periods (Amundson et al. 2015) and are associated with benefits such as improvements in soil moisture and nutrient retention due to better aggregate stability, which also enhances permeability and subsequent infiltration (Gaudin et al. 2015). Such improvements to soil health can translate into long-term economic benefits for farmers (Nowak 2013; NRCS 2015); however, the value of improved or retained soil is often not directly assessed in the context of short-term economic decision making made at the farm scale (Cruse et al. 2012). Therefore, tension exists, across agriculturally productive regions, between short-term economic goals of minimizing costs (profit maximization) and efforts to preserve and enhance soil resources for the long term (Carlisle 2016; Cruse et al. 2012). Across much of the Corn Belt there has been an acceleration of intensive production on more marginal lands due in part to an increased demand for corn-based ethanol, incentivized by various iterations of the renewable fuel standard (Bain and Selfa 2013), and associated increases in the price of commodity goods (Wright and Wimberly 2013). Generally, farmers have to make seasonal decisions that emphasize the economic viability of their farm operation, which may be counter to achieving longer-term resilience. Resilient cropping systems can be envisioned as systems that are “able to retain yield potential and recover functional integrity (produce food and feed) when challenged by environmental stresses” (Gaudin et al. 2015:1).

While much research has examined what motivates farmers’ use of soil conservation practices (Arbuckle and Roesch-McNally 2015; Atwell, Schutte, and Westphal 2009; Ervin and Ervin 1982; Gould, Saupe, and Klemme 1989; Knowler and Bradshaw 2007; Prokopy et al. 2008; Reimer, Thompson, and Prokopy 2012), less is understood about how farmers approach managing soil resources to reduce weather-related risks. Through this research effort we sought to answer the following questions: How do farmers approach managing their soil resources to sustain their farm operation and adapt to weather-related risks? How are farmers’ efforts to enhance and preserve soil temporally situated (i.e., short-term interests vs. long-term management goals)? In this article we use a grounded theory approach (Charmaz 2006) to examine in-depth interviews with farmers ($n = 159$) from nine out of eleven Corn Belt states (see Figure 1). We asked farmers questions regarding their motivations for adopting and utilizing soil and water conservation practices (e.g., no-till farming and cover crops), and we probed their adaptive responses to increased weather variability. Through analysis of the farmer interviews, the construct of a “soil stewardship ethic” emerged to help explain how some farmers are actively adopting, enhancing, and maintaining soil conservation practices to ensure more resilient soils in response to more variable and extreme weather. Further, this work also explores how farmers who have articulated a soil stewardship ethic are reconciling short-term productivist goals with long-term conservation goals and in doing so may point toward an emergent aspect of a conservationist identity.

In the following section we outline a literature review that informed the analysis, followed by a methods and results section. In the discussion section, we propose a conceptual framing that highlights the emergent dynamics of the soil stewardship ethic, including some ideas about what drives the development of the ethic and what actions it may inspire. We propose areas for future research on assessing the soil stewardship ethic construct’s reliability and validity, in addition to pragmatic communication approaches that may be used to engage farmers in conversations about reducing climate risks on their farms. Finally, the conclusion proposes that the soil stewardship ethic, by helping to bridge short-term productivist goals and long-term conservation goals, may facilitate greater resilience at the farm scale, while suggesting that further work is needed to better understand the construct and its connection to extant theories on identity and notions of the good farmer.

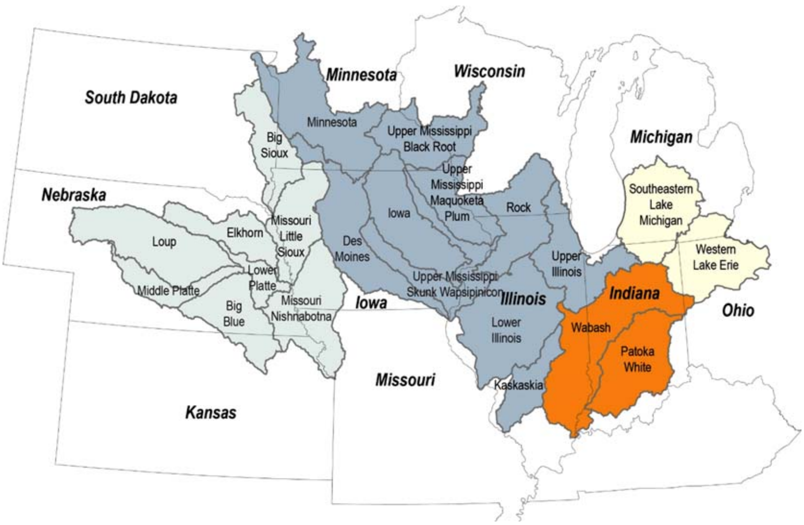

Figure 1. Map of states and key HUC6 (hydrologic unit code) watersheds that make up the U.S. Corn Belt. [Color figure can be viewed at wileyonlinelibrary.com]

Soil Stewardship and Soil as a Social-Ecological Feedback

In coupled human and natural systems, such as farming, people and nature interact "reciprocally and form complex feedback loops" (Liu et al. 2007:1513). The social and biophysical worlds are co-constituted, characterized by a dynamic interplay in which the biophysical world is shaped by social processes and, in turn, social phenomena are shaped by the biophysical world (Freudenberg, Frickel, and Gramling 1995). Specific to the farming enterprise, farmer management decisions impact soil resources, and soil resources constrain and enable management decisions through a social-ecological feedback—via reciprocal interactions (Schneider et al. 2012). For example, farmers observe gully and sheet erosion in their fields, which can encourage them to use no-till farming or cover crops to reduce erosion problems (Romig et al. 1995).

Farmers' experiences with newly adopted conservation practices can facilitate a new "relationship" with their soil resources, which can, in turn, enable them to observe and experience soil in new and different ways. Such experiences can lead to changes in identity and ethics, which assists farmers in putting a greater emphasis on conservation. Coughenour (2003) found that Kentucky farmers who adopted no-till farming began to develop a new appreciation for their soil resources. This new relationship with the soil helped these farmers to shift their identity from a more productivist orientation, with its emphasis on short-term profitability as well as yield and productivity, to what he identified as "practical agroecologists working with the soil and plant environments" (295), or what some identify as a conservationist identity that emphasizes proenvironmental attitudes and behavior (Sulemana and James 2014). Further, Coughenour (2003) found that this newly activated identity led farmers to seek new ways to balance both profitability and conservation. In this way, shifts in farmer identity can help to reshape what constitutes ideas about what makes a "good farmer," which is reaffirmed through relationships and cultural norms (Burton 2004; Hyland et al. 2015; McGuire, Morton, and Cast 2013; Sulemana and James 2014) and may help to change what farmers define as good farming practices (Quinn, Quinn, and Halfacre 2015). Shifting notions of what a good farmer is has been shown to help explain changes in conservation practice adoption (Burton 2004; McGuire et al. 2013). Through a shift in appreciation of soil resources, as argued by Coughenour (2003), farmers became committed to long-term implementation of new practices (i.e., no-till farming) that aligned better with their new identity.

Prior research on soil conservation illuminates a number of factors, including agronomic, economic, government policy, and normative factors, that influence farmer adoption of soil health practices (Carlisle 2016; Ervin and Ervin 1982). Specifically, the perceived need for soil conservation and improvement is an important factor in the adoption of soil-conserving practices in intensive row cropping systems (Atwell et al. 2009; Ryan, Erickson, and De Young 2003), particularly driving the use and adoption of conservation tillage (Coughenour 2003; Gould et al. 1989; Knowler and Bradshaw 2007) and cover crops (Arbuckle and Roesch-McNally 2015; Reimer et al. 2012). Rogers's (1995) seminal work on diffusion of innovations clarifies that articulated needs and experienced problems were an important aspect of his broader concept of prior conditions that are a precursor to the five stages of the innovation-decision processes that can effectively drive adoption.

The diffusion-of-innovations theoretical work has contributed to a deeper understanding of how technological innovations, including conservation practices, are adopted and diffused within target communities (Rogers 1995). One of the main contributions of diffusion-of-innovations theory is a broader understanding of how specific technology and practice characteristics may be more likely to persuade a farmer to adopt new innovations. These five characteristics, outlined by Rogers (1995), require that the innovations and practices will have relative advantage over other technologies being used, are compatible with current values (compatibility), are not overly complex, can be tested (trialability), and are observable (15). Rogers suggested that the more a new practice or technological innovation exhibited these characteristics, the more likely a farmer would be to adopt it. However, this model has been critiqued for not fully explaining conservation adoption in both the United States and the developing world (Barham 1997; Coughenour 2003; Ersado, Amacher, and Alwang 2004; Fuglie and Kascak 2001; Lee 2005; Padel 2001), suggesting that other critical factors also influence farmer adoption of conservation practices.

Conventional corn and soybean farmers across the Corn Belt are primarily operating within a productivist system that is oriented toward maximizing yield and profit (Blesh and Wolf 2014); however, farmers' decisions to manage soil resources more sustainably are not solely driven by economic goals of increased productivity and efficiency. Farmer decision making is situated within diverse environmental, political, economic, and cultural contexts that vary at different spatial scales (Gray and Gibson 2013; Harden et al. 2013; White et al. 2009). Specifically, Harden et al. (2013) found that along with the economic and agronomic ideals of productivist agriculture that emphasize yields and profitability, Corn Belt farmers' management actions were also influenced by commitments to family, land, and community. Accordingly, decision making can be characterized as a tension between both formal rationality, the quantitative calculation of costs and benefits, and substantive rationality, which incorporates other "ultimate values," including ethical, political, cultural, and normative factors (Weber 1978).

Conservation and other farm management decisions should also be considered "within the context of much broader structural imperatives and power dynamics that shape and influence the kind of relationships farmers and other producers" seek to establish (Lawrence, Cheshire, and Richards 2004:224). These structural forces shape markets, economics, and access to credit and ultimately help to determine whether there is an enabling decision environment that facilitates decision and action (Pielke, Sarewitz, and Byerly 2000; Roncoli 2006). Land managers, therefore, face a constrained choice with regard to how they make decisions and whether they can actually put those decisions into practice in their operation due to larger social and economic conditions beyond the farm gate (Hendrickson and James 2005; Hildebrand and Wilsey 2008). In all, an array of drivers—not simply economic rationality—influence farmers' decisions to use soil conservation practices (Hyland et al. 2015; Kalcic et al. 2014; Sattler and Nagel 2010; Sulemana and James 2014; Thompson, Reimer, and Prokopy 2015).

Data and Methods

We conducted in-depth interviews with 159 farmers from nine Corn Belt states: Illinois (9), South Dakota (14), Missouri (16), Ohio (18), Indiana (20), Iowa (20), Minnesota (20), Michigan (20), and Wisconsin (22). The interviews were conducted as part of a project funded by the USDA National Institute of Food and Agriculture, the Climate and Corn-Based Cropping Systems Coordinated Agricultural Project. The project was a partnership between 10 universities and two USDA Agricultural Research Service labs that brought together an interdisciplinary team of biophysical and social scientists including soil scientists and agronomists, sociologists, economists, agricultural engineers, modelers, and climatologists, as well as extension educators and farmers. The overall goal of the project was to conduct research on adaptive and mitigative strategies that could be implemented across the U.S. Corn Belt to decrease agriculture's vulnerability to the impacts of climate change.

At the outset of the project, the Climate and Corn-Based Cropping social scientists worked with the project's 19 extension educators to develop a recruitment and interview research plan. The extension educators were asked to recruit 20 corn farmers from each state who fit the following selection criteria: that they have at least 80 acres of corn the previous planting season and would be willing to participate in activities over the course of the five-year project. Potential farmer participants were sent letters explaining the project and expectations associated with participation, and offered a $100 incentive for participation. The interviews were conducted when farmers first agreed to be part of the project and prior to participation in any project-wide activities to minimize the impact of project participation on their responses. The extension educators who recruited the farmers from their networks tended to characterize them as slightly more progressive and conservation oriented than typical corn and soybean farmers in the local areas from which they were recruited. Since a major objective of the project was to understand farmer perspectives on conservation practices and climate change, this was seen as beneficial.

Interviews with farmers lasted between 45 and 90 minutes, following a semistructured interview protocol with follow-up questions designed to probe motivations and expand on topics that emerged out of the in-depth interviews. The interview protocol was composed of four sections that covered perspectives on the use of conservation practices (with an emphasis on nutrient management, tillage, and cover crops), experienced weather variability, beliefs about climate change, trusted information sources, and attitudes about sustainability and cropping system diversity (see the Appendix for the entire interview protocol). Analysis of the in-depth interviews focused on farmers' discussions of soil health and erosion prevention and their reported strategies for reducing weather-related risks. Farmers were interviewed during a historically wet 2013 growing season following the 2012 drought, which affected a large portion of the U.S. Midwest. The region as a whole has been experiencing more extreme weather events, including heavy rain events and longer periods of drought (Pryor et al. 2014), so the timing of the interviews was appropriate for exploring farmers' perspectives on dealing with and adapting to weather extremes.

Interviews were digitally recorded and transcribed verbatim with analysis conducted in NVivo 10. We examined interview transcripts using grounded theory following an open, axial, and selective coding procedure (Charmaz 2006); grounded theory is an inductive approach to analyzing rich qualitative data. It is important to note, however, that we did not use theoretical sampling, which is commonly used in grounded theory, for this study. We wrote theoretical memos, which are an integral tool for conducting qualitative analyses using a grounded theory approach (Charmaz 2006), throughout the coding process in order to build conceptual density of key concepts. We explored each category to validate the findings and to ensure reliability, by assessing the power of the category to explain the phenomenon of interest, the usefulness of the category, and broader patterns within and between different categories (Charmaz 2006). These theoretical memos and an iterative coding procedure allowed researchers to ensure that farmer quotations included in each category accurately reflected the broader meaning of the category without too much overlap between different categories. As Prokopy (2011) suggests, direct quotes are included in the findings section to illustrate key concepts and assure transparency.

During the preliminary coding process, we developed a coding typology based on the available literature on how farmers assess soil health properties. Later coding efforts built on how farmers talk about, and manage for, soil health, particularly in the context of increased weather variability. Specifically, discussions regarding soil health and erosion prevention were not a primary focus of the interviews but rather they emerged out of the discussions with farmers as they volunteered information about their approach to conservation and responses to weather-related events on their farm. This study, therefore, is grounded in the emergent concepts that developed out of conversations with farmer participants. We used a grounded theory approach to develop a conceptual understanding of the emergent construct of a "soil stewardship ethic," which may prove useful in understanding how farmer identity may influence behavior. We developed this construct through qualitative analysis, which includes three subcategories: responding to weather-related risks, bridging short- and long-term goals, and observing neighbors. These subcategories are used to organize and present the findings.

Findings

Most farmer participants reported gross farm sales between $250,000 and $500,000, which places them in the "medium-sales small family farm" ($150,000−$349,999) and "large family farm" ($350,000−$699,999) categories, as defined by the USDA Economic Research Service (Hoppe and MacDonald 2013). Nearly all participants were white males, although some women who reported they were the primary farm manager were interviewed with their male spouses. Almost all had at least some college education. Participants had a farm size of 281 hectares on average. All of the participants produced corn, most employed a crop rotation that included soybeans, and some used an extended rotation that included crops such as alfalfa and small grains. Around a third had cattle, hogs, or other livestock in their operations. In terms of conservation practices, the majority of participants had adopted some form of reduced tillage to minimize soil disturbance and leave crop residue for soil protection, either by using conservation tillage or no-till farming. Over half were experimenting with cover crops to some extent. These rates of reduced tillage and cover crops are higher than those estimated for the region as a whole,[1] which aligns with extension educators' subjective assessments that participants were somewhat more conservation oriented than the norm for their local areas.

Soil Stewardship Ethic

We developed a "soil stewardship ethic" construct through the iterative coding process outlined in the methods section. This construct emerged through examination of the ways that farmers articulated the benefits of erosion prevention and improvements in soil health, particularly in the context of reducing weather-related risks on their farms. The soil stewardship ethic is conceived as a philosophy that guides

[1] Based on agricultural census data for 2012, for the states where farmers were interviewed, on average, 3 percent of total cropland was in cover crops, around 25 percent in conservation tillage, and 28 percent in no-till (NASS 2014b). Many farmers use a combination of conservation tillage and no-till on their cropland.

conservation actions that farmers take on their farms and influences their perspectives on what a sustainable operation might look like on their farm. We developed subcategories in order to examine what constitutes this emergent soil stewardship ethic; these subcategories include responding to weather-related risks, observing neighbors, and bridging short-term productivist goals and long-term conservation goals (Table 1).

The subcategory of "responding to weather-related risks" represents the ways in which farmers are approaching the management of their soil resources to mitigate weather-related risks, through the use and adoption of conservation practices. The "observing neighbors" subcategory emerged out of conversations with farmers who described how they observe and compare their soil management approaches to neighboring farms. The subcategory of "bridging short-term productivist goals and long-term conservation goals" exemplifies the ways that farmers are articulating the need to preserve and enhance soil resources for the current and future productivity of their farm operations with an emphasis on future generations. Additionally, this subcategory illustrates how farmers sought to reconcile the tension between short-term profit-oriented goals and long-term soil conservation objectives. Overall, findings suggest that a commitment to proactively managing soil resources is a key component of a soil stewardship ethic particularly in the context of reducing long-term vulnerability to more extreme and variable weather.

Responding to Weather-Related Risks

Farmers' experiences of more extreme weather events caused some to shift their production practices to focus on soil health and erosion prevention through the adoption of conservation practices such as no-till farming and the use of cover crops. Multiple farmers discussed ways that experiences of extreme rain events and drought had motivated them to adopt practices that enhance soil resources. Here are a couple of examples regarding how farmers discussed changes they had made to their tillage regime in response to different weather extremes,

> The springs of '10 and '11 were quite wet, large rain events, and we are seeing more erosion, more dirt moving than we should see on some of those fields so we are trying to move to a system, a strip till system for corn on corn that we can get comfortable with using on this highly erodible land. (Illinois farmer)

Table 1. Details for Subcategories of the Soil Stewardship Construct.

Soil Stewardship Ethic Subcategory	No. of interviewees	Description	Typical Quote
Responding to weather-related risks	65	Enhancing soil resources, often discussed as improving soil health; including strategies to adapt to weather-related risks, with tensions between management tweaks vs. adaptive strategies to improve soil	Even a few of the fields that we own, the lighter ground, we do more no-till on that, might be part of the reason we got and switched to a no-till drill for the beans. [We are] trying to conserve some moisture, kind of thinking ahead a little bit, without disturbing the soil, and help build a little organic matter too. (Wisconsin farmer)
Observing neighbors	19	Observations of soil erosion, water movement on neighboring farms; broadly discussing soil impacts to the area after large wind and rain events	Well I look at his [field] and I look at mine. I mean, if I notice his, I look a little bit more at mine ’cause I can see what’s going on. So that’s what brings your attention to things. (Iowa farmer)
Bridging short-term productivist goals with long-term conservation goals	52	Direct contemplation of the farmers’ role in preserving the productivity and sustainability of the farm for future generations. Farmers try to reconcile short-term goals of profitability with long-term goals of conservation	If we were to farm this land that we’ve been given . . . to us for the next 100 years, as it has been farmed and cultivated for the previous 100 years, then we are going to diminish this natural resource that we’ve been blessed with. . .. I think that, as stewards of the soil, we should prioritize on making that [soil], making that a very important thing. (Indiana farmer)

> We, historically, have been conventional tillage. This year, I have switched almost all the acres to no-till, thinking it was going to be dry. I’d been thinking about it for about 5–6 years but I’m a little slow to act on it, I guess. (South Dakota farmer)

Many of the farmers interviewed discussed the benefits of reducing tillage or shifting to no-till farming as a way to improve soil health and reduce erosion with the added benefit of mitigating weather-related risks. Fifty-four farmers specifically stated that they were reducing tillage to diminish weather-related risks on their farms. Additionally, utilization of cover crops was another practice viewed as having soil health and erosion prevention benefits that farmers, many of whom were beginning to experiment with cover crops, suggested might help make their farm operations more resilient to extreme weather events. Twenty-one farmers specifically mentioned incorporating cover crops in order to reduce weather-related risks on their farms. The importance of using no-till farming and cover crops for reducing weather-related risks was articulated by a Michigan and an Iowa farmer:

> We seem to be having these extremes from one year to the next. Like this year it was way too wet. Last year, it was plenty dry. The year before that, it was cold and wet, initially, and then it got too dry after that. I guess you just need to be flexible. Obviously, you can't do anything about the rain but, ... you ... [can not] work your ground to death and ... leave residue on the ground. No-tilling [farming is] what you're going to [do to] conserve more moisture than if it's wide open and getting baked by the sun. (Michigan farmer)

> You're trying to think ahead and say, how can I make that soil more resilient or able to handle the stresses ..., whether it's a dry stress or too much rain or something like that, you know? By having that structure and those roots there [from using cover crops] and holding on to that soil and maybe, hold on to more nutrients through [the winter]. (Iowa farmer)

Many farmers also discussed how their use of best management practices has enhanced soil health by improving water infiltration rates during periods of heavy rain and maintaining soil moisture during drought. Typically, farmers discussed these as benefits of reduced tillage and no-till farming. A Minnesota and a Wisconsin farmer highlighted that emphasis:

> That's another factor that I feel I have an advantage with the no-till and strip till is it's just a way to manage the water that we're given. You know, with the better soil, anything I can do to maximize the infiltration and keep the water on my ground instead of running off down the ditch. (Minnesota farmer)

> Well, I just think, through the years, we've just gone to the point of trying to maximize all the moisture that's available. In

> other words, through the reduced tillage, through the no-till, just trying to make efficient use of what we have and not opening up the ground any more than what we have to, trying to utilize moisture the best we can. (Wisconsin farmer)

Additionally, some farmers expressed the thought that improving soil health through adoption of cover crops might help to address some of the negative impacts of larger storm events. This is exemplified by a farmer from South Dakota, who said, "I would guess that [climate change] means bigger rainfall events so the impetus to keep soil in place and to do cover crops is probably going to be something that we're going to have to pay much more attention to."

While many participants talked about the benefits of reducing tillage, 20 of them were actually talking about moving toward more intensive tillage in response to cooler and wetter springs. These farmers discussed increasing their tillage, particularly in the spring, to get the ground dried out enough to plant. For example, a farmer from Iowa said, "So, you know, the ground's got to be dry to do no-till and then sometimes the ground just don't dry out unless you, you know, scratch it up a little bit. So you know there are pros and cons of [no-till].... Like last year when it was so dry, no-till was a pretty smart thing to do. And then ... you'll have years where you just got to do what you got to do." While many farmers acknowledge the soil health and conservation benefits of reducing tillage, some have found it tricky to implement on their farms due to the management impact of more extreme weather events (e.g., late spring planting due to more frequent rain), as well as underlying biophysical factors associated with their soil resources. This illustrates the ways in which some conservation goals may be in conflict with a farmer's pragmatic needs (e.g., getting a crop established, yield management). As a farmer from Missouri put it, "I tried to no-till and some of our soils are just really wet and heavy and they don't warm up in the spring and I've just found that [with] the deep tillage, over the years, you certainly get a yield bump from the tillage because you're loosening the soil." These farmer sentiments illustrate a tension between building soil resources, via improvements in soil management practices, and short-term, seasonally reactive adjustments that they make to address the negative impacts of weather events.

The analysis of data in the subcategory of responding to weather-related risks highlights that many farmers are proactively adapting to increased weather variability by engaging in practices that enhance and preserve their soil resources over time in direct response to experienced weather on their farms. Some farmers, however, are responding to seasonal variability primarily through increased tillage, which, while providing some short-term benefits (e.g., drying soils more quickly), may have negative impacts on soils over the long term. Thus, although most farmers we interviewed indicated they were taking steps to adapt to climatic changes, farmers who were increasing tillage might actually be undermining the long-term health and productivity of soil; in other words, these farmers are reacting in maladaptive ways.

Observing Neighbors

Throughout the course of the interviews, farmers referenced the actions of their neighbors, and other farmers in their farming community. In the context of soil stewardship, farmers often discussed their neighbors' tillage regimes and the ways in which the impacts of big weather events influenced their approach to soil conservation. In some cases, farmers were disappointed with how their neighbors treated their own soil resources. This was articulated by farmers who noted:

> You know there are times you get those huge rains and, you know, . . . you drive around and you see guys who are just totally disregarding it, that just have a disaster. And then even the people who are trying hard, can lose a little dirt but . . . I think it's [soil preservation] got to be something that's constantly in the back of your mind. (Iowa farmer)

> You know, last week or the week before when we had that big rain, you know, you can look at all these ditches and see all the mud and everything going down through there and you're thinking, you know, if them guys had just been out there and left it alone, you wouldn't have all that running down through there like that, that color [running brown]. (Indiana farmer)

Through these sentiments expressed by farmers, one gets the sense of the very public nature of farming, whereby actions taken on the landscape, particularly those that lead to erosion, are highly visible to the community and neighbors. There is a sentiment of blame and frustration among some farmers who see and experience the consequences of actions taken on surrounding land:

> I just get tired of cleaning my ditches out when I'm the guy below the neighbor and all this silt's coming down here in the spring, you know. He's always complaining about . . ., oh, he

> got a hard rain. Well, we all got a hard rain, you know. (Indiana farmer)
>
> I mean, our neighbor, he works his ground every year. Half of it's a sand knoll. Why he works it is absolutely beyond me. I can look up and see it and it's just blowing across onto my field. I should send him a thank-you note for the topsoil. (Michigan farmer)

In many cases, observations of neighbors and other cropland in their community inspired farmers to have confidence in their own conservation practices and ethics, which they might articulate as being "better" for the soil than what certain neighbors were doing. Many referenced these comparisons as a rationale for their use of no-till farming. These farmers used their observation of neighbors' practices to affirm their own conservation efforts. However, farmers also expressed a challenge with reconciling their practices with their neighbors' different ones, particularly when it came to getting out in the fields early in the spring. This is particularly true for farmers who practice no-till farming because they typically have to wait longer to get out in the field than their neighbors because tillage can dry out and warm up soils more quickly than no-till farming.

Some farmers also suggested that their neighbors simply do not give some practices enough time to allow for soil benefits to accrue, which they suggest has caused some of their neighbors to revert back to more intensive management (e.g., increased tillage). This is illustrated by a South Dakota farmer, who said, "So . . . [neighbors will] no-till for two or three or four years and then they'll till. And then you get all that organic matter decomposing and they say, 'See, I do a much better job with tillage.'" This farmer argued that because the benefits of no-till accrue over a longer period, many farmers are not willing to wait to experience the benefits and thus revert back to more intensive tillage. In some cases, this lack of willingness to wait for benefits to accrue may also have to do with the fact that some farmers lack a complete understanding of how no-till farming can improve soil health, particularly over time. In other words, these farmers who are questioning their neighbors' actions are arguing that these other farmers are not aware that there is a temporal component to improving soil resources. These farmers note that some of their neighbors are simply unwilling to take the necessary time to learn, observe, and appreciate the benefits of conservation practices as they manifest in soil improvements.

The subcategory of observing neighbors illustrates that farmers acknowledge the public nature of the farming enterprise; after all, farmers are able to observe their own and others' actions on the land with obvious impacts, such as erosion and drainage problems, they being difficult to hide from public view. These farmers acknowledge that observing neighboring farmers' mismanagement of soil resources provided a signal to them to reorient their own production practices to better steward their soil resources, or, at times, these observations served to reinforce farmers' beliefs that their current approach to managing soil resources was superior to that of their neighbors. Typically these observations occurred after experiences of extreme weather events (e.g., flooding, big rains) that impacted all farmers in their communities.

Bridging Short-Term Productivist Goals and Long-Term Conservation Goals

During interviews, farmers were asked what the long-term sustainability of their farm operation means to them. This question provided insight on how farmers define the sustainability of their operations, given that the term can take on multiple meanings depending on the context and audience. Nearly a third of the farmers talked about the importance of preserving the land, or their "ground," particularly for the benefit of future generations, as evidenced in a few key quotes:

> But I guess, morally, the sustainability is to keep doing the best of our ability for good stewardship of the soil for the next generations.... We need to be careful and preserve it [soil] for next generations and leave our legacy behind. (Missouri farmer)

> I'll probably have grandchildren and we want to keep that water supply good for them. And also to keep the soil [in] good condition so that the generations from now can still produce food that they're going to need. (Iowa farmer)

Thus, soil conservation is viewed as a connection between farmers' current operations and future generations, which helps them to make linkages between short- and long-term goals. While this was often referred to in the context of preserving their farmland for grandchildren or others who might inherit the farm, there were broader discussions about the importance of maintaining the agricultural land base for the production of food and feed for the benefit of society more broadly.

Interview participants also discussed the long-term nature of preserving soil, noting that reducing soil erosion and improving soil health assisted them in thinking about the productivity of their land over time, not just on a seasonal basis, as the following remarks demonstrate:

> Well, I guess the way I look at it is if my farm, if the ground I farm is going to be sustainable for the long term, you know, it's got to be able to maintain its productivity and increase its productivity and the most important thing for me is you can't do that without the soil and I need to take care of the soil. (Minnesota farmer)

> But long term, I mean, you have to be aware of what you're using in the soil and take care of it. I mean you can't just let it all wash away. You have to keep it in a good state of fertility. (Illinois farmer)

Several farmers also explicitly described the tension between their goals of maximizing short-term productivity and maintaining soil health and productivity over the long term. This tension is illustrated by two quotes from farmers who have sought to marry long-term soil stewardship goals with short-term productivity goals:

> You know, if you're focused on maximizing production, you might not necessarily be doing what's best for the soil, short term. But I think, you know, I'm kind of leaning towards what's best for the soil. . . . If I take care of the soil in the short term, long term, my yields will reflect that. (Minnesota farmer)

> Well it's always economics. And that's followed by land stewardship. You know, you have to be a good steward of the soil because that's what pays the bills. If we destroy the soil, you know, that's short term and it's not going to be replaced. I mean, economics is always first. Conservation is right there with it, of course. (Wisconsin farmer)

Another farmer described how he wrestles with the difficulty of achieving long-term soil stewardship goals given the short-term impetus to make a profit: "To get to the long term, we have to get through the short term to turn the profit. That has to be there to get us through the short term. Long term, I'm a little bit conflicted on that. Absolutely, well, [what] I'm not conflicted on is, absolutely, we have to save our soil. If we lose our soil, we have nothing to work with" (Missouri farmer). This quote articulates the struggle that exists for farmers who, in many cases, believe they need to maximize profits on a yearly basis, while also trying to achieve other goals of taking care of their soil resources. A Wisconsin farmer, who primarily uses no-till farming but has shifted to fewer rotations and more corn-corn rotations, summed it up by saying, "the bottom line is you got to do whatever makes you the most money, taken the fact that you want to keep the soil in good health, you know, as far as erosion and such but the market will dictate."

While there is a tension between the short-term profit imperative and long-term sustainability concerns, many of the farmers that we interviewed are attempting to bridge the short and long term by drawing connections between yield and healthy soils. For example, a Michigan farmer expressed these linkages by saying, "organic matter . . . gives you better soil tilth, which gives you the microbial activity, which gives you the better soil health, better soil structure, better yields, more money." Emerging from these farmer sentiments is the idea that an ethic focused on preserving and enhancing soil health has helped farmers to take a longer-term view of landscape-level change, articulated by a South Dakota farmer who said, "I truthfully don't believe that 100 years from now that people will continue to till in the form that they do, I think their productivity will probably start to taper off or just pop for them. Where[as] people with more reduced tillage and no-till will probably just continue to increase their yields. So, you know, I'm trying to think long term." Such beliefs highlight the idea that, through specific management practices that emphasize enhancement of soil health, some farmers are trying to harmonize their short-term yield and profit-oriented goals with longer-term goals of sustaining soil resources for the long term.

The subcategory of bridging short-term productivist goals and long-term conservation goals illustrates that many farmers acknowledge that preserving and enhancing soil resources is a long-term project that requires proactive management. Farmers are drawing linkages between conservation goals, such as preserving soil through erosion prevention and enhancing soil health, and broader goals for maintaining productivity on their farm over the long term. These farmers articulated a growing understanding that soil is not just another input for their row-crop production system; rather soil forms the foundation of a productive farming operation that will sustain them, and generations to come. Many of the farmers interviewed have resolved, or are trying to resolve, tensions between short-term goals of profitability and long-term goals for conservation. These farmers expressed the belief that soil provided a fundamental connection between on-farm profitability and their vision for the long-term sustainability of their farm operation for the benefit of future generations.

Discussion

Using a grounded theory approach to analyze in-depth interviews with farmers in the U.S. Corn Belt, we identified an emergent soil stewardship ethic that helped to explain farmers' responses to extreme weather events and the adoption, maintenance, and enhancement of soil conservation practices. We provide a conceptual framing (Figure 2) that examines what factors influence the emergence of a soil stewardship ethic and how this ethic then encourages farmers to make changes to their operation. The figure begins with a conceptualization of the prior conditions that provide the context for the emergence of the soil stewardship ethic and the adoption of new or improved practices. Prior conditions, according to Rogers (1995), set the stage for the innovation-decision process by conceptualizing the broader context of the decision-making frame that ultimately influences adoption of new practices or technologies. These prior conditions include the existing set of practices that we characterize as vulnerable conventional agricultural approaches that often lead to soil degradation and erosion. Rogers also suggests that a prior need or problem identification is a precursor to adoption of new practices, which highlights our findings that illustrate how farmers' experiences with extreme weather events inspired them to observe and reflect on changes in the quality of the soil on their own farm and on neighboring farms, which helped to activate a soil stewardship ethic. This ethic then guides the adoption, maintenance, and enhancement of soil health building practices (e.g., reduced tillage, cover crops, and diversified rotations). This social-ecological feedback then enables farmers to reconcile short-term productivist goals with long-term conservation and stewardship goals. Conceptually, this shift may lead to more resilient soil resources over time, although more research is needed to test whether there is evidence of this at the field scale.

Figure 2. Conceptual framing of emergent findings that characterize one way to think about causal pathway associated with the cultivation of a soil stewardship ethic.

The importance of observing neighbors in the development of a soil stewardship ethic illustrates that farmers' ability to observe their own and others' action on the land can allow them to more fully assess the environmental and economic consequences of mismanaging soil resources. For some farmers, this provided a signal to reorient their own production practices to better steward soil resources. Early work on the adoption and diffusion of agricultural technology highlights the critical importance of farmers' observing practices (observability) on other farms before adopting a new technology on their farm (Rogers 1995); later research has confirmed the importance of farmers' social networks, and subsequent shifts in norms that define who a good farmer is, particularly as that definition relates to facilitating farmers' adoption of conservation practices that emphasize on-farm sustainability (Atwell et al. 2009; Carolan 2006; Coughenour 2003; Pannell et al. 2006). Monitoring of neighboring fields enables farmers to judge farming performances (e.g., observing practices and their consequences on neighboring fields) as a way to obtain, or maintain, status as a good farmer (Burton 2004). In this way, farmers are observing their neighbors' practices while also reflecting on their own practices, and in doing so are redefining what practices constitute a good farmer. Farmers may begin to develop new norms that affirm actions taken to prevent erosion and improve soil quality. Our findings suggest that observing practices on neighboring farms, particularly those that have a negative impact on soil resources (e.g., soil erosion), can inspire adoption of new practices or enhance the use and experimentation of existing practices, which encourage the emergence of the soil stewardship ethic, thus assisting them in reconciling production and conservation goals.

The results of this research suggest that farmers' efforts to address temporal trade-offs through the cultivation of a soil stewardship ethic, and subsequent adoption or maintenance of conservation practices, enable them to resolve tensions between a productivist identity, characterized by short-term reactivity to exogenous factors, such as weather and markets, in order to maximize yield and profitability, and a conservationist identity that is aligned with proenvironmental attitudes. Our findings suggest that a soil stewardship ethic may influence farmers' identities and can also help them to redefine normative ideas about what makes a "good farmer," thus encouraging them to make improvements in soil health and erosion control. It is possible that both productivism and conservationism are aspects of the soil stewardship ethic, which may improve the way that farmers in the Corn Belt are able to enhance both the economic and environmental sustainability of their operations. However, further work is needed to examine the role between identity and subsequent action, as some researchers have found limited connections between identity and subsequent action (Thompson et al. 2015). Further work is needed to assess how closely the soil stewardship ethic is aligned with notions of farmer identity and how this identity drives behaviors that materially improve soil quality.

Despite the cultivation of this soil stewardship ethic, many farmers clearly articulated the pragmatic challenge of reconciling production-oriented goals, which demand profitability on a yearly basis, with longer-term goals for soil preservation and enhancement. Political and economic factors, such as policy and markets, can drive farmers toward greater exploitation of their natural resources over the short term, despite the benefits that might accrue to them over the long term from greater soil conservation (Ashby 1985). Farmers embedded in the productivist paradigm often struggle to reconcile short-term economic goals with ecological goals of preserving soil and water resources (Gray and Gibson 2013). Farmers are thus incentivized to emphasize annual profitability, particularly in an era of decreasing marginal returns, due to increases in seed and chemical costs (NASS 2014a) and historically high rental rates (Secchi et al. 2008). Maintaining annual profitability may be increasingly challenging due to the volatility of commodity markets and increased weather variability (NOAA 2011), and thus efforts to improve soil resources may be difficult to achieve, particularly if these changes carry additional costs to farmers.

Incentive-based policy mechanisms may be needed to bridge short-term profitability concerns and longer-term conservation goals in order to make soil quality more relevant to market-based decisions made by agricultural actors (Nowak 2013). Enacting such policy changes alone however, may not remove all barriers to improving soil health practices because cultural and identity barriers associated with farmer worldviews may still exist and may impede farmers from taking action. In other words, shifting perspectives on soil stewardship may be challenging if a farmer's worldview articulates clear boundaries between agricultural (e.g., productivist) and environmental (e.g., conservationist) approaches to farming, therefore they may not be motivated to take action to improve conservation regardless of policy incentives (Stuart, Schewe, and McDermott 2012).

Findings from this study reinforce prior research that has found that land managers respond to social-ecological feedbacks on their farms, leading them to alter their land use practices to improve ecosystem services provisioning (Lambin and Meyfroidt 2010), including improvements to their soil resources (Coughenour 2003). Many farmers noted that once they had changed practices, such as decreasing tillage or adding cover crops, they experienced an improvement in their soil quality, often assessed through better water infiltration rates or reduced compaction. For some farmers, however, the experience of increased cool and wet spring weather, in particular, led a number of them to increase their use of tillage to hasten the warming and drying of fields. Although such actions might provide economic benefits to farmers over the short term by allowing earlier planting of cash crops, over time increases in tillage can damage soil health (Morton et al. 2015). Such potentially maladaptive reactions to weather-related risks can be expected to lead to greater vulnerability over time through the degradation of soil resources (Cruse et al. 2012). Further research is needed to fully explore the differences between the farmers who have developed a soil stewardship ethic that has encouraged them to adopt, maintain, and enhance conservation practices and farmers who are more likely to maintain their use of conventional agriculture practices that increase their vulnerability to increased weather variability over time.

This study highlights key elements that constitute aspects of an emergent soil stewardship ethic. Further efforts are needed to operationalize this concept. It may be useful for future researchers to develop measures for this emergent construct. Measures might include items that focus on the three components of the soil stewardship ethic identified in this article: soil stewardship as a strategy for coping with weather extremes, the importance of observing other farmers in order to reflect on current practices, and the ways that a soil stewardship ethic addresses tensions between short-term productivist goals and long-term conservation goals. It will be important to devise effective ways to measure how identity and notions of what constitutes a good farmer interface with a soil stewardship ethic (see Roesch-McNally, Arbuckle, and Tyndall [2016] for productivist and conservationist constructs based on Corn Belt survey research). Additionally, the normative component of observing one's neighbors is a critical component of the soil stewardship ethic, therefore including the role of social networks and the normative influence of other farmers' actions, evidenced in the prominence of observability, in efforts to measure the concept of a soil stewardship ethic is important. Finally, there are interdisciplinary opportunities for engaging farmers in field-level research to assess whether farmers who express attitudes associated with the soil stewardship ethic are actually improving soil resources on their farms through the adoption and use of conservation practices. In this vein, interdisciplinary research should build on farmer and scientist partnerships to develop programs that will "monitor, assess, and build healthy soil"

(Romig et al. 1995:236) particularly as such actions mitigate weather-related risks.

Conclusion

Through extensive in-depth interviews with farmers across nine Corn Belt states, we examined how farmers respond to weather-related risks and projected climate change. Our findings illustrate a potential resolution, via soil stewardship, of the problem of the apparent trade-off between short-term productivist goals and longer-term soil and water conservation goals that may lead to greater agroecosystem resilience. Many farmers in our study articulated a soil stewardship ethic, which emerged in response to experiences with more extreme and variable weather on their farm and observations of their own and neighboring farmers' soil resources. Cultivation of a soil stewardship ethic may motivate farmers to adopt, maintain, and enhance the use of soil conservation practices that will foster more resilient agricultural systems, an urgent imperative as climate-change-related weather extremes increase vulnerability of conventional agroecosystems (Cruse et al. 2012). Our findings suggest that there may be a connection between the soil stewardship ethic and extant theories on farmer identity. Further research is needed to test this emergent concept to assess how well it explains farmer behavior with regard to mitigating weather-related risks and enhancing soil resources over the long term.

The results of this research suggest that efforts to engage farmers in conversations about soil stewardship, which emphasizes a message of enhancing soil health to mitigate weather-related risks and preserving soil resources for future generations, may be a pragmatic approach for engaging farmers in efforts to reorient their farm production practices to be more resilient in the face of a changing climate. The Natural Resources Conservation Service implemented its Soil Health Initiative in 2012 (NRCS 2015) with the goal of encouraging farmers to maintain healthy and productive soil resources, through the use and adoption of no-till farming, cover crops, and more diverse crop rotations. The findings from this research provide empirical evidence that the Conservation Service and other global soil initiatives are building programs that are likely to be received well by farmers.

The climate is changing and more farmers may need to implement adaptive practices that are more transformative than using no-till farming and cover crops; these transformative practices might include crop and livestock integration and greater cropping systems diversity (Hatfield et al. 2014). A transformation in agricultural production highlights the need for a more multifunctional agriculture that will deliver agricultural goods (e.g., food, fuel, fiber) and other ecosystem services (e.g., carbon sequestration and water quality improvements) to society (Jordan and Warner 2010; Robertson and Swinton 2005). Addressing these larger issues will require multiscale changes in human institutional activities that currently reinforce policy and market incentives that maintain current production systems (Blesh and Wolf 2014; Coughenour 1984). Individual farmers may adapt to climate change by adopting this soil stewardship ethic, yet as long as policies and markets, which tend to emphasize production at the cost of greater on-farm sustainability (Stuart et al. 2012), continue to structure the broader agroecosystem, it may be difficult to bring about broader landscape-scale changes. Thus further efforts must examine whether the development of a soil stewardship ethic may help to enable a more resilient agriculture in the Corn Belt by assisting farmers to reconcile productivist and conservationist goals that would allow for more innovative and transformative social-ecological outcomes (Folke 2006).

References

Amundson, Ronald, Asmeret A. Berhe, Jan W. Hopmans, Carolyn Olson, A. Ester Sztein and Donald L. Sparks. 2015. "Soil and Human Security in the 21st Century." *Science* 348(6235):647–53.

Arbuckle, J. Gordon and Gabrielle E. Roesch-McNally. 2015. "Cover Crop Adoption in Iowa: The Role of Perceived Practice Characteristics." *Journal of Soil and Water Conservation* 70(6):418–29.

Ashby, Jordan A. 1985. "The Social Ecology of Soil Erosion in a Colombian Farming System." *Rural Sociology* 50(3):377–96.

Atwell, Ryan C., Lisa A. Schulte, and Lynne M. Westphal. 2009. "Landscape, Community, Countryside: Linking Biophysical and Social Scales in US Corn Belt Agricultural Landscapes." *Landscape Ecology* 24:791–806.

Bain, Carmen and Teresa Selfa. 2013. "Framing and Reframing the Environmental Risks and Economic Benefits of Ethanol Production in Iowa." *Agriculture and Human Values* 30: 351–64.

Barham, Elizabeth. 1997. "Social Movements for Sustainable Agriculture in France: A Polanyian Perspective." *Society and Natural Resources* 10(3):239–49.

Blesh, Jennifer and Stephen A. Wolf. 2014. "Transitions to Agroecological Farming Systems in the Mississippi River Basin: Toward an Integrated Socioecological Analysis." *Agriculture and Human Values* 31:621–35.

Burton, Robert J. F. 2004. "Seeing through the 'Good Farmer's' Eyes: Towards Developing an Understanding of the Social Symbolic Value of Productivist Behavior." *Sociologia Ruralis* 44:195–216.

Carlisle, Liz. 2016. "Factors Influencing Farmer Adoption of Soil Health Practices in the United States: A Narrative Review." *Agroecology and Sustainable Food Systems* 40(6):583–613.

Carolan, Michael S. 2006. "Social Change and the Adoption and Adaptation of Knowledge Claims: Whose Truth Do You Trust in Regard to Sustainable Agriculture?" *Agriculture and Human Values* 23:325–39.

Charmaz, Kathy. 2006. *Constructing Grounded Theory*. London, England: Sage.

Coughenour, C. Milton. 1984. "Social Ecology and Agriculture." *Rural Sociology* 49(1): 1–22.

———. 2003. "Innovating Conservation Agriculture: The Case of No-Till Cropping." *Rural Sociology* 68(2): 278–304.

Cruse, Richard M., Scott Lee, Thomas E. Fenton, Eheng Wang, and John Laflen. 2012. "Soil Renewal and Sustainability." Pp. 477–501 in *Principles of Sustainable Soil Management in Agroecosystems,* edited by R. Lal and B. A. Stewart. Boca Raton, FL: CRC Press.

Ersado, Lire, Gregory Amacher, and Jeffrey Alwang. 2004. "Productivity and Land Enhancing Technologies in Northern Ethiopia: Health, Public Investments, and Sequential Adoption." *American Journal of Agricultural Economics* 86(4):321–31.

Ervin, Christine A. and David E. Ervin. 1982. "Factors Affecting the Use of Soil Conservation Practices: Hypotheses, Evidence and Policy Implications." *Land Economics* 58(3): 277–92.

Folke, Carle. 2006. "Resilience: The Emergence of a Perspective for Social-Ecological Systems Analysis." *Global Environmental Change* 16:253–67.

Freudenberg, William R., Scott Frickel, and Robert Gramling. 1995. "Beyond the Nature/Society Divide: Learning to Think about a Mountain." *Sociological Forum* 10(3): 361–92.

Fuglie, Keith O. and Catherine A. Kascak. 2001. "Adoption and Diffusion of Natural Resource Conserving Agricultural Technology." *Review of Agricultural Economics* 23(2):386–403.

Gaudin, Amélie C. M., Tor N. Tolhurst, Alan P. Ker, Ken Janovicek, Cristina Tortora, Ralph C. Martin, and William Deen. 2015. "Increasing Crop Diversity Mitigates Weather Variations and Improves Yield Stability." *PLOS One* 10(2):e0113261–e0113281.

Gould, Brian W., William E. Saupe and Richard M. Klemme. 1989. "Conservation Tillage: The Role of Farm and Operator Characteristics and the Perception of Soil Erosion." *Land Economics* 65(2):167–82.

Gray, Benjamin J. and Jane W. Gibson. 2013. "Actor-Networks, Farmer Decisions, and Identity." *Culture, Agriculture, Food and Environment* 35(2):82–101.

Harden, Noelle M., Loka L. Ashwood, William L. Bland and Michae M. Bell. 2013. "For the Public Good: Weaving Multifunctional Landscape in the Corn Belt." *Agriculture and Human Values* 30:525–37.

Harris, Robin F., Douglas L. Karlen, and David J. Mulla. 1996. "A Conceptual Framework for Assessment and Management of Soil Quality and Health." *Methods for Assessing Soil Quality* 49:61–82.

Hatfield, J., G. Takle, R. Grotjahn, P. Holden, R. C. Izaurralde, T. Mader, and E. Marshall. 2014. "Agriculture." Pp. 150–74 in Melillo, Richmond, and Yohe 2014.

Hendrickson, Mary K. and Harvey S. James. 2005. "The Ethics of Constrained Choice: How the Industrialization of Agriculture Impacts Farming and Farmer Behavior." *Journal of Agricultural and Environmental Ethics* 18(3):269–91.

Hildebrand, Peter E. and Daniel S. Wilsey. 2008. "Understanding Farmer Decision Making in the Face of Rapid Change in Columbia and Suwannee Counties, Florida." Pp. 353–60 in *8th European IFSA Symposium: Empowerment of the Rural Actors: A Renewal of Farming Systems Perspectives,* edited by Benoit Dedieu and Sylvie Zasser-Bedoya. Saint-Genès-Champanelle, France: INRA SAD.

Hoppe, Robert A. and James M. MacDonald. 2013. *Updating the ERS Farm Typology, EIB-110.* Washington, DC: U.S. Department of Agriculture, Economic Research Service.

Hyland, Jerry J., Davey L. Jones, Karen Andrew Parkhill, and A. Prysor Williams. 2015. "Farmers' Perceptions of Climate Change: Identifying Types." *Agriculture and Human Values* 33(2):323–39.

Jordan, Nicholas and Keith D. Warner. 2010. "Enhancing the Multifunctionality of US Agriculture." *BioScience* 60(1):60–66.

Kalcic, Margaret, Linda Prokopy, Jane Frankenberger, and Idrajeet Chaubey. 2014. "An In-depth Examination of Farmers' Perceptions of Targeting Conservation Practices." *Environmental Management* 54:795–813.

Knowler, Duncan and Ben Bradshaw. 2007. "Farmers' Adoption of Conservation Agriculture: A Review and Synthesis of Recent Research." *Food Policy* 32:25–48.

Lal, Rattan. 2014. "Societal Value of Soil Carbon." *Journal of Soil and Water Conservation* 69(6):186A−92A.

Lambin, Eric F. and Patrick Meyfroidt. 2010. "Land Use Transitions: Socio-ecological Feedback versus Socio-economic Change." *Land Use Policy* 27:108–18.

Lawrence, Geoffrey, Lynda Cheshire, and Carol Ackroyd Richards. 2004. "Agricultural Production and the Ecological Question." Pp. 221–36 in *Controversies in Environmental Sociology*, edited by R. White. Cambridge, England: Cambridge University Press.

Lee, David R. 2005. "Agricultural Sustainability and Technology Adoption: Issues and Policies for Developing Countries." *American Journal of Agricultural Economics* 87(5): 1325–34.

Lehman, R. Michael, Cynthia A. Cambardella, Diane E. Stott, Veronica Acosta-Martinez, Daniel K. Manter, Jeffrey S. Buyer, Jude E. Maul, et al. 2015. "Understanding and Enhancing Soil Biological Health: The Solution for Reversing Soil Degradation." *Sustainability* 7:988–1027.

Liu, Jianguo, Thomas Dietz, Stephen R. Carpenter, Marina Alberti, Carl Folke, Emilio Moran, Alice N. Pell, et al. 2007. "Complexity of Coupled Human and Natural Systems." *Science* 317:1513–16.

McGuire, Jean, Lois W. Morton and Alicia D. Cast. 2013. "Reconstructing the Good Farmer Identity: Shifts in Farmer Identities and Farm Management Practices to Improve Water Quality." *Agriculture and Human Values* 30:57–69.

Melillo, Jerry M., Terese C. Richmond and Gary W. Yohe, eds. 2014. *Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment.* Washington, DC: U.S. Government Printing Office.

Montanarella, Lee. 2015. "Agricultural Policy: Govern Our Soils." *Nature* 528:32–33.

Morton, Lois W., Jon Hobbs, J. Gordon Arbuckle and Adam Loy. 2015. "Upper Midwest Climate Variations: Farmer Responses to Excess Water Risks." *Journal of Environmental Quality* 44:810–22.

NASS (National Agriculture Statistics Service). 2014a. *Farm Economics: Record High Agriculture Sales; Income and Expenses Both Up.* Washington, DC: U.S. Department of Agriculture.

———. 2014b. *State and County Data.* Washington, DC: U.S. Department of Agriculture.

NOAA (National Oceanic and Atmospheric Administration). 2011. *Annual Climate Prediction Applications Science Workshop Report.* Ames, IA: Climate Science Program, Iowa State University.

Nowak, Peter. 2013. "Thinking about a Future Conservation Agenda." *Journal of Soil and Water Conservation* 68(2):50A−52A.

NRCS (Natural Resources Conservation Service). 2015. *Soil Health.* Washington, DC: U.S. Department of Agriculture. Retrieved December 15, 2015 (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/).

Padel, Susanne. 2001. "Conversion to Organic Farming: A Typical Example of the Diffusion of an Innovation?" *Sociologia Ruralis* 41:40–61.

Pannell, David J., Graham R. Marshall, Neil Barr, Allan Curtis, Frank Vanclay, and Roger Wilkinson. 2006. "Understanding and Promoting Adoption of Conservation Practices by Rural Landholders." *Australian Journal of Experimental Agriculture* 46:1407–24.

Pielke, Roger A., Daniel Sarewitz, and Radford Byerly. 2000. "Decision Making and the Future of Nature: Understanding and Using Predictions." Pp. 361–88 in *Predictions, Science, Decision-Making and the Future of Nature*, edited by Roger A. Pielke. Washington, DC: Island Press.

Prokopy, Linda S. 2011. "Agricultural Human Dimensions Research: The Role of Qualitative Research Methods." *Journal of Soil and Water Conservation* 66(1):9A−12A.

Prokopy, Linda S., Kristin Floress, Denise Klotthor-Weinkauf and Adam Baumgart-Getz. 2008. "Determinants of Agricultural Best Management Practice Adoption: Evidence from the Literature." *Journal of Soil and Water Conservation* 63(5):300–11.

Pryor, Sara C., Donald Scavia, Charles Downer, Marc Gaden, Louis Iverson, Rolf Nordstrom, Jonathan Patz, and G. Philip Robertson. 2014. "Midwest." Pp. 418–40 in Melillo, Richmond, and Yohe 2014.

Quinn, Courtney E., John E. Quinn and Angela C. Halfacre. 2015. "Digging Deeper: A Case Study of Farmer Conceptualization of Ecosystem Services in the American South." *Environmental Management* 56(4):802–13.

Reimer, Adam P., Aaron W. Thompson and Linda S. Prokopy. 2012. "The Multidimensional Nature of Environmental Attitudes among Farmers in Indiana: Implications for Conservation Adoption." *Agriculture and Human Values* 29:29–40.

Robertson, G. Philip and Scott M. Swinton. 2005. "Reconciling Agricultural Productivity and Environmental Integrity: A Grand Challenge for Agriculture." *Frontiers in Ecology and the Environment* 3(1):38–46.

Roesch-McNally, Gabrielle, J. Gordon Arbuckle, and John Charles Tyndall. 2016. "What Would Farmers Do? Adaptation Intentions under a Corn Belt Climate Change Scenario." *Agriculture and Human Values* 34(2):333–46. doi:10.1007/s10460-016-9719-y.

Rogers, Everett M. 1995. *Diffusion of Innovations*. New York: The Free Press.

Romig, Douglas E., M. Jason Garlynd, Robin F. Harris and Kevin McSweeney. 1995. "How Farmers Assess Soil Health and Quality." *Journal of Soil and Water Conservation* 50(3): 229–36.

Roncoli, Carla J. 2006. "Ethnographic and Participatory Approaches to Research on Farmers' Responses to Climate Predictions." *Climate Research* 33:81–99.

Ryan, Robert L., Donna L. Erickson, and Raymond De Young. 2003. "Farmers' Motivations for Adopting Conservation Practices along Riparian Zones in a Mid-western Agricultural Watershed." *Journal of Environmental Planning and Management* 46(1): 19–37.

Sattler, Claudia and Uwe Jens Nagel. 2010. "Factors Affecting Farmers' Acceptance of Conservation Measures: A Case Study for North-eastern Germany." *Land Use Policy* 27: 70–77.

Schneider, Flurina, Dominik Steiger, Thomas Ledermann, Patricia Fry, and Stephan Rist. 2012. "No-Tillage Farming: Co-creation of Innovation Through Network Building." *Land Degradation & Development* 23(3):242–55.

Secchi, Sylvia, John C. Tyndall, Lisa A. Schulte, and Heidi Asbjornsen. 2008. "High Crop Prices and Conservation: Raising the Stakes." *Journal of Soil and Water Conservation* 63(3):68A−73A.

Stuart, Diana, RebeccaL. Schewe, and Michael McDermott. 2012. "Responding to Climate Change: Barriers to Reflexive Modernization in U.S." *Agriculture, Organization and Environment* 25(3):308–27.

Sulemana, Iddisah and Harvey S. James. 2014. "Farmer Identity, Ethical Attitudes and Environmental Practices." *Ecological Economics* 98:49–61.

Thompson, Aaron W., Adam Reimer, and Linda S. Prokopy. 2015. "Farmers' Views of the Environment: The Influence of Competing Attitude Frames on Landscape Conservation Efforts." *Agriculture and Human Values* 32:385–99.

Weber, Max. 1978. *Economy and Society*. Berkeley, CA: University of California Press.

White, Stacey Swearingen, J. Christopher Brown, Jane W. Gibson, Eric Hanley, and Dietrich H. Earnhart. 2009. "Planting Food or Fuel: Developing an Interdisciplinary Approach to Understanding the Role of Culture in Farmers' Decisions to Grow Second-Generation, Biofuel Feedstock Crops." *Comparative Technology Transfer and Society* 7(3):287–302.

Wright, Christopher K. and Michael C. Wimberly. 2013. "Recent Land Use Change in Western Corn Belt Threatens Grasslands and Wetlands." *Proceedings of the National Academies of Science* 110(10):4134–39.

Appendix: Interview Protocol Used to Guide In-Depth Interviews with Corn Belt Farmers

Thematic Area	Interview Questions
Conservation practices	• Could you describe your nutrient management system? Including your main motivations for managing nutrients the way you do? • What tillage do you use on these fields and what were your motivations for using them? What are the primary benefits of your tillage approaches? And are there any challenges associated with these tillage approaches? Where do you get information on these methods? • If you use cover crops, when did you start using them and what were your motivations for starting? What species do you use? What are the primary benefits of your cover crop approach? Are there challenges associated with using cover crops on these fields? Where do you get your information on cover crops? • [*IF* Farmer does not use cover crops then he was asked if he had ever used them and why he stopped using them as well as whether he would consider using them in the future.] • Have you ever heard of drainage water management? If so, what do you think about it? • Have you ever heard of nitrogen sensors? If so, what do you think about them? • What, if any, practices do you implement differently on land you own as opposed to land you rent?
Weather variability	• Over the past five years or so, have you experienced any extreme weather that has adversely affected your farm operation? • Have these weather events changed your management practices at all? If so, how? • There have been a lot of discussions lately about global climate change and its potential impacts on agriculture. What are your opinions about climate change and its potential impacts on your farm operation? • [*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?] • [*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?]
Trusted sources of information	• Who do you look to for information on conservation management practices? 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? • What can extension, government, or the private sector do to assist further development of conservation practices on your farm? • What types of programs or policies do you think might assist you participating in more conservation programs or implementing new/different management practices?
Sustainability	• Can you describe what long-term, on-farm sustainability means to you? • Let's think about your marginal field right now, or other marginal areas on your whole farm, and consider other uses that might be

Appendix. ***Continued***

Thematic Area	Interview Questions
	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? • 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?