Knowledge Networks and Adaptation of New Agricultural Systems:

Cover Cropping in North Central Illinois

BY

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DISSERTATION

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List of Abbreviations

AC	Apostolic Christian Church
BMP	Best Management Practice
CBMP	Council on Best Management Practices
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
HUC	Hydrologic Unit Code
IDOA	Illinois Department of Agriculture
MCCC	Midwest Cover Crop Council
MRBI	Mississippi River Basin Healthy Watershed Initiative
NLRS	Nutrient Loss Reduction Strategy
NRCS	Natural Resources Conservation Service
SHP	Soil Health Partnership
SWCD	Soil and Water Conservation District
USDA	United States Department of Agriculture
VHWP	Vermilion Headwaters Watershed Partnership

Summary

Rational planning models often include knowledges mainly derived from top-down, state-sponsored institutions. Such a model has been heavily critiqued in planning literature for its failure to address community level concerns and include divergent knowledges. The failure of rational, state-centered planning is nowhere more pervasive than in agriculture in the U.S. Corn Belt, yet industrial agricultural systems continue to proliferate, even amid growing concerns over soil health and water quality. Conservation agriculture efforts to promote conservation practices, such as cover cropping, that improve soil health and water quality continue to come primarily from the state, but recently, state-backed policy, pioneer farmers, and agricultural groups are calling for a more place-based approach to agricultural planning. The recent shift, however, still has not inspired widespread adoption of cover cropping, indicating a need for a middle ground, including multiple, place-specific strategies and knowledges.

This research utilizes a case study approach to explore the degree to which types of knowledge networks (from scientific to local to integrated) influence cover cropping adoption among farmers. I employ an actor network theory method to identify the impact of histories, landscapes, institutional actors, and conservation policy that make up knowledge networks in the Vermilion Headwaters in north central Illinois. The theory is more beneficial compared to other approaches in that it better elucidates divergent knowledges in the watershed and allows me to show how farmers and agricultural professionals use such knowledges when adopting conservation practices.

Through interviews with farmers and agricultural professionals, participant observation, and document review, informed by pragmatic planning and actor network theory, I find that farmers operating within mixed knowledge networks are more likely to adopt cover cropping than farmers only involved in scientific or local knowledge networks. Not all farmers adhere to this pattern, however, thus, from an in-depth, grounded analysis, I conclude that farmers adopting cover cropping are likely to experience three key moments: inspiration, collaboration, and experimentation.

Summary (continued)

Urban and agricultural planning, then, may find it useful to bolster conservation planning programs and policies that not only encourage the integration of knowledges but also create the conditions for the three moments to occur if practices like cover cropping are to become widespread. Although the study is generalizable only to north central Illinois, methods can be replicated to study similar farmer groups in other Corn Belt watersheds to further build on my findings.

Chapter 1 – Introduction

The rise in modern, state-centered planning coincided with the proliferation of industrialized agriculture following the Second World War. Whereas much of urban planning has since moved away from relying on solely centralized knowledge and toward a more deliberative approach, agricultural planning in the U.S. has generally continued to focus on expert, state-disseminated knowledge, even in the development of efforts to integrate conservation into agricultural practice. Yet, the tenets of the rational planning model have not gone away in urban planning, as it has uses in data driven techniques and advanced technologies to solve local and global problems. Simultaneously, agricultural planning has created space for deliberative planning, environmental stewardship, and community well-being as it works to promote conservation practices (James Jr., 2006). As urban and agricultural planning ebb and flow, from top-down state and corporate-sponsored development to deliberative, communicative, and environmentally-sound practices, a more pragmatic approach—focused on network building and integrated knowledges—may provide a middle ground for multiple, place-specific decision-making strategies. There may be lessons from agricultural planning, still more situated in state-centered top-down planning but more recently finding its way in deliberative processes, that can be applied to urban planning, particularly as the successes and failures of agricultural conservation efforts leave such visible marks on the landscape, farm by farm.

A dearth of literature exists that looks at whether the type of knowledge network—within which individual actors make their decisions—actually transforms the individual's behavior toward public purposes. If shared knowledge production, as opposed to top down or bottom up knowledge production, leads to public-oriented decisions by individuals, then planning may want to focus on means to create spaces for shared knowledge, not just so that it can make a better recommendation or plan, but so that it can shape collective behaviors.

This study explores how farmers, situated in myriad contexts and networks, create and use knowledges to adopt innovating conservation practices. Furthermore, I investigate whether the type of knowledge network affects whether or not farmers adapt to cover cropping, as a particular innovative farming practice promoted by the state as a conservation tool. If it does, planners may want to work to create spaces for mixed knowledges as a tool to shape behavior. This study also looks at the degree to which planning, in broad terms, has played a role in creating mixed knowledge around adaptive agricultural strategies, and if it has, when it has been effective.

The Problem for Planning

In *Seeing Like a State*, James Scott (1998) argues against modern, state-centered planning schemes for their uniform design and often authoritarian approach. Likewise, Sandercock (1998) describes the "crumbling pillars of modernist planning wisdom," citing the processes of socio-cultural change, a rebellious citizenry, as well as a change in social theory. Although state-centered planning often fails to recognize the myriad citizenry (even under the guise of advocacy planning), Scott contends that the rational planning model can allow for easier experimentation, modeling, and centralized management, which is highly useful when governments need to intervene early in epidemics; account for food security; understand economic trends that greatly affect public welfare; and make lifesaving policy decisions based on demographic and other data (1998, p. 77).

Scott first gives the example of scientific forest management plans in Germany in the mid-1900s, which quickly eliminated previous forest conditions that offered the peasantry access to plants for medicinal uses, charcoal and wood for heat, and other resources. State strategy to turn the forest into a singular commodity (Norway Spruce and Scotts Pine) succeeded in a national economic sense but at the expense of peasantry livelihoods and the natural environment. The stripped-down forest was much easier to manage and provided job opportunities for a relatively unskilled labor force. Although the "scientific forest" was a success in the short run, it was a disaster to forest ecologies and peasants, who still found ways through practical improvisation and/or illegal acts to collect wood and other provisions. Even so, the German model has since been replicated as the forestry standard throughout the world (Scott, 1998).

On the other hand, bottom up planning can also prove problematic. Gilchrist, Mallory, and Merkel (2005) caution the validity of bottom up planning that relies solely on local knowledges, based on the authors' research on wildlife management in Hudson Bay, Canada. In some cases, lack of detail led to insufficient data for wildlife management strategies, and other information was wholly inaccurate.

Another approach that might push planning more to the middle is insurgent planning as a response to state-sponsored projects. High modernist city planning in Brasília offers an example of planners' failure to consider the daily life of a country's population. First generation residents initially moved to the new city on its builders' promise to escape the crowded and corrupt streets of other Brazilian cities. After only a few years, however, much of the city's low-income residents and workers were pushed to the periphery in unplanned settlements, but also pushed back in the form of resistance and subversion. The planned space itself also shaped residents' behaviors. For example, the lack of informal gathering spaces, so prevalent in Brazil's surrounding built environment, created spatial segregation, which led to squatter homes and illegal development. One might also consider the more recent example in Chicago of public school closings, based mainly on the city's budget constraints and much less on the education of the youth or teachers' rights (Ashby & Bruno, 2016). The resulting teacher strikes are indicative of how state-centered schemes can often spur individual and collective divergent behavior that later invokes multiple actors' inputs.

To be certain, local knowledges do on their own contribute much to place-specific scenarios. Local peoples in Hudson Bay were able to track and detect population changes among migratory birds, providing key information otherwise unknown to scientists (Gilchrist et al., 2005). In a neighborhood in Brooklyn, Corburn (2003) reports that a community resident group was proactive in creating a detailed assessment of small polluters, acting on their own behalf because state air monitors did not detect these small polluters. Alone, however, contextual knowledges may struggle to find a place within broader neighborhood and city-wide strategies for improvement, so insurgent planning, although useful, often fails to find institutional footing to create broader change. Corburn thus argues for a co-production of knowledges.

Such co-production is invoked in John Forester's critical pragmatism, which calls for co-constructed planning practices and appreciation of multiple forms of knowledge (2013). This brand of pragmatism also seeks to address power relations that dictate the effectiveness of knowledge claims.

Doing so, involves critical exploration of planning processes and planning institutions. Scott advocates that planning institutions be shaped in part by local knowledges. Even at the time of Scott's writing this was not something new to planning. John Friedmann, in *Retracking America* (1973), also acknowledges the value of local, experiential planning and argues for a concept of *mutual learning*, in which science-based experts and the public together engage in the planning process (Sandercock, 1998). Corburn's example in Brooklyn offers insight into how professional planners and lay people can work together to co-produce knowledges for project formation and problem solving.

Rydin (2007) suggests that in creating a collaborative planning framework, however, planning must distinguish between engaging different knowledges and engaging different voices. Doing so helps thwart the contemporary practice of consensus building on the basis of common values only, which "may not be best suited to ensuring that the most appropriate knowledge influences decision making" (p. 55). Rydin raises institutional concerns by questioning the role of the planner in handling multiple knowledges. Implementing *local* knowledges within the planning process has indeed proven difficult, as certain institutions and non-scientific forms of knowledge are in many contexts still seen as impediments to state-centered development and environmental management projects (Agrawal, 1995).

As shown, however, knowledge communities or networks shape and produce knowledge in relation to and within political structures and should not be neglected. These knowledge networks made up of various actors—both state-sponsored and local, human and non-human—necessarily inform community practices, whether divergent or cooperative, through the interactions with other people and the physical environment. Although the co-production of knowledge is now well received within planning (Rydin, 2013), the mechanisms by which integrated knowledge networks create changes in individual behavior leading to changes in collective outcome are less understood. Rydin (2007) proposes that the first step is for planners to identify arenas to engage, test, and recognize different knowledges. One such arena is agriculture.

The Problem for Agriculture

Agricultural institutions are a part of extensive, interconnected knowledge networks. Historically in the U.S., however, these institutions (such as the state and federal Department of Agriculture, university extension agencies, soil and water conservation districts, and the Farm Bureau) operate as progenitors of research, policy, and knowledge, often prescribing uniform solutions to complex environmental, economic, and social concerns. Presently, the state-prescribed, standardized, large-scale practices, a cornerstone of industrial agriculture in the United States over the last almost 70 years, have led to environmental degradation at the local level and contributed to global climate change (Foley et al., 2005; Horrigan, Lawrence, & Walker, 2002). The industrial agricultural system in the Midwest is dominated by commodity crops often exported and manufactured as livestock feed, bio-fuel, or as plastic substitutes. These cash crops, mainly corn and soybean, are grown using primarily conventional methods with heavy emphasis on synthetic chemical inputs to manage weeds and disease and to enhance crop growth. Farmers, operating amid broad institutional and environmental contexts, affect the local ecology through various decision-making processes that lead to actions carried out in different agricultural practices.

Conversely, farmers operating outside the shadow of Westernized agriculture place emphasis on what is considered alternative agricultural practices. In West Africa, farmers, relying on traditional and place-based knowledges in practicing polycropping (the norm in 80 percent of West Africa’s farmland), continue to dodge pressures from state and corporate sponsored agricultural reformers (Scott, 1998). Although such practices may lead to improved soil fertility, among other environmental and social benefits, Western agriculture also includes place-specific technologies geared towards improving soil fertility. Misiko (2010) documents the struggle of smallholder farmers in Kenya to adopt such practices, even when smallholders are included in the research process. In the U.S., conventional farmers can also be resistant to adapting to conservation practices, whether state-sponsored or locally driven.

Programs and policies that promote conservation best practices can often be environmentally beneficial but sometimes are not adopted by farmers due to a variety of reasons. Llewellyn (2007) finds that farmers often do not adopt innovative practices because a wealth of farming information already exists, making new information hard to retain, let alone integrate. The author argues that the solution lies in how this information is passed along and the quality of the information. The author suggests that farmers most often integrate information when it is locally derived and farm-specific. This is because decisions to adopt alternative practices are in part informed by knowledge systems that are situated amid specific micro-environments. Such practices encourage sustainable crop and food production in some cases, while mitigating local and global environmental damage, as well (Foley et al., 2005).

Cover cropping, for instance, has gained popularity in the Midwest throughout the Corn Belt states, including Iowa, Illinois, and Indiana, as farmers face growing pressure to adapt to changing climates and cash crop price fluctuations, in addition to continued concern over loss of soil and depleted soil health. Furthermore, the growing hypoxic zone in the Gulf of Mexico led to the creation of the United States Department of Agriculture (USDA)-sponsored Mississippi River Basin Healthy Watersheds Initiative (MRBI) to address water quality concerns. MRBI employs a watershed approach, in which partners at all levels collaborate to carry out localized strategies. Large research universities, non-profit organizations, county conservation districts, seed companies, and farmers now drive a modest research and implementation agenda, in efforts to turn the tide and improve declining conditions. However, cover cropping still lacks widespread adoption (Arbuckle & Roesch-McNally, 2015; CTIC, SARE, ASTA, 2015; USDA, ERS, NASS, 2012).

Cover cropping adds another annual crop (e.g., cereal rye, oats, radishes, etc.) to the rotation and studies report multiple benefits, including the cropping system's ability to fix and add nutrients to the soil, protect against soil erosion, and increase the yield of the following cash crop, in addition to regionally-improved water quality (Arbuckle & Roesch-McNally, 2015; CTIC, SARE, ASTA, 2015; Kaspar & Singer, 2011). Lack of place-specific knowledges and institutional support are among the key barriers growers face in implementing such ecologically sound practices (Arbuckle & Roesch-McNally, 2015), as internal and external actors may not always be aware of local knowledges and knowledge networks that exist. Literature suggests that integrated local knowledge can play a vital role in shaping institutions and encouraging farmers to adopt certain best practices (Corburn, 2003; Olsson & Folke, 2001). Despite barriers, the farming landscape in the Midwest appears to be changing slowly, as research suggests a slow uptake in adaptation of cover cropping (Agricultural Professional 6, personal communication, May 5, 2017). However, it remains unclear how farmers (as well as planners) participation in different knowledge networks has played a role in such change.

Both planning and agriculture struggle amid rising political, social, and environmental pressures, and either exclusively top down or bottom up approaches have yet to meet the need of local populations. Even when environmentally beneficial practices find their way into conventional systems, lack of localized institutional support, integrated and place-specific knowledges, and flexible conservation policy inhibits the spread of such practices. Working together, state-sponsored planning and agriculture must continue the efforts of small watershed groups, with greater attention to making space for multiple voices and knowledges to promote sound practices.

Study Overview

My research reveals how farmers create and use knowledges that lead to adaptation to innovative conservation practices. I explore the relationship between types of knowledge networks (from local to scientific) and the emerging conservation cropping system of cover cropping. To do so, the present research focuses on landscapes, ancillary institutions, and farmers that together constitute knowledge networks. This research describes the nuances of knowledges embedded in farmer, institutional, and land relationships and highlights the presence and efficacy of integrating experiential knowledge or local ecological knowledge—a system that at a basic level "consists of pieces of information, or 'facts,' resulting from simple cognition of objects in the environment and their cause-and-effect, spatial, and temporal relationships" (Brodt, 2001, p. 102). Olsson and Folke (2001) define local ecological knowledge as knowledge "held by a specific group of people about their local ecosystem" that concerns the interplay among organisms and their environment (p. 87). After a review of knowledge systems, food systems, and political ecology literature, only a few studies exist on the role of knowledge networks and their influences on conservation practices in the contiguous United States (Carolan 2006a; Carolan 2006b; Coughenour, 2003).

The purpose of my study, then, is to identify divergent knowledges amid top-down knowledge networks within an innovating conservation agricultural system in the Midwest, recognizing the degree to which knowledges are integrated among different actors and to understand their role in shaping conservation practices. Scott (1998) asserts that the modern U.S. agricultural system is dominated by a scientific knowledge that simplifies environments but fails to handle complexities wrought in the farming landscape. Kloppenburg (1991) problematizes the "hegemony of existing science" that limits a "range of knowledges" among farmers. The author instead encourages the "construction of an alternative agriculture." Kloppenburg proposes power be handed over to farmers given their ability to generate workable alternatives and calls for researchers to help "bring farmers and their local knowledge back into formal knowledge production for agriculture" (p. 531). Theoretically, I understand the knowledge production process to be carried out through knowledge networks formed among intertwined relationships, as Coughenour states, "all entities, regardless of their materiality, are produced in relations" (2003, p. 280). Coughenour also asserts that overlapping systems of knowledge within a crop production strategy constitute the "networks of relationships" among the various actors. Thus, cover cropping as a crop production strategy demands new partnerships, new technologies, and new and integrated knowledges in order to succeed.

Before the fieldwork began, I postulated that fostering place-specific knowledges and integrated or mixed knowledge networks may allow farmers to better understand and work within dynamic environmental and social systems and lead them to adapt to more suitable conservation best management practices. More specifically, I hypothesized that individual farmers who are engaged in integrated knowledge networks are more likely to use cover cropping as an alternative to conventional cropping systems and that sub-watersheds dominated by such knowledge networks are more likely to have a higher percentage of farmers who employ alternative practices, including cover cropping. Furthermore, I expected that planners' roles are to push state-sponsored research and policy agendas, without the consideration of watershed and farm level contexts.

I realize that a mix of different knowledges are employed simultaneously and do not wish to criticize scientific knowledge, only to consider how farmers integrate other knowledges that may be more useful and possibly encourage the adaptation to practices that are better able to handle environmental change.

Research Framework

This study employs a political ecology framework, as it deals with the interplay of environmental and resource management—knowledge as a resource in this case—and human interactions with the environment. Farming is situated amid a complex physical landscape but is also deeply influenced by political, economic, and social forces. Although the structural forces certainly impact knowledge production and dissemination, Grossman (1993) warns that a political ecology framework "should not imply a lessening of attention to the intricate, complex interactions in human-environment systems that are at the heart of traditional cultural-ecological studies" (p. 348). He continues by stating that changing patterns of cropping practices are just as relevant to political ecologists.

One tool of analysis that has its roots in Machiavelli and later Bruno Latour and has recently been adopted by political ecologists is actor network theory. The theory is more of an ontology than epistemology in that it views humans and non-humans as equally important in forming networks. Actor network theory at its core is interested in how power works and uses tools, such as interviews and document review, to focus on interactions among key actors (Spinuzzi, 2008). From the interactions and negotiations, actor network theory seeks to explain how certain circumstances come to be. For my purpose, actor network theory is applicable in that the theory provides a lens to explore different networks and interactions among farmers, planners, and the environmental and social conditions, in which they are a part. Doing so, I illuminate the particular knowledges and planning schemes that allow for certain agricultural practices to emerge. Along the way, the theory allows me to understand the integration of experiential knowledges in the planning process, what importance knowledges may hold in such process, what actors are most influential, and how practice is thus affected. Rydin (2013) applies actor network theory to understand planning practice and finds the theory is well suited to handle the relationship between humans and the material world, especially where technology and the environment intersect.

In regard to planning theory, pragmatic planning, a theory at the heart of contemporary planning practice, coincides with actor network theory but does not fully engage with the material world. Nonetheless, the theory is useful in my research as it asserts the planners' role must be to facilitate the process of learning by doing (Hoch, 2007). The planner-as-outsider still exists but the definition of planner is extended to a multiplicity of community members, institutional personnel, and other professionals. Under this theory, interactions among farmers and planners play a vital role in affecting and shaping their environments. Through my research, I integrate elements of actor network theory with a pragmatic planning approach. In addition, I borrow from a form of traditional pragmatism, social interactionism, to focus on farmer interactions with others and the environment.

From this framework, my research employs a case study approach that compares the presence of different knowledge systems and networks among farmers who have adapted to cover cropping and those who have not. I focus on a particular place, the Vermilion Headwaters sub-watershed in Livingston and Ford County in north central Illinois, located amid a vast industrial agricultural landscape of the U.S. Corn Belt. I explore the influence knowledges produced within these networks has on adaptation of alternative agricultural practices. I identify existing knowledge types and networks through primarily interviews and participatory observations with farmers and agricultural professionals in the sub-watershed.

Research Questions and Significance

My central research question that guides my study is: How do farmers, situated in myriad contexts and networks, create and use knowledges to adopt conservation practices? Methodologically, I explore this question by addressing the following five questions:

1. What is the extent of cover cropping?
2. What knowledge systems and knowledge network types are present?
3. What is the relationship between types of knowledge networks and adaptation to cover

cropping?

4. To what degree do other factors, beyond knowledge networks, play a role in cover cropping adaptation, including planning institutions and policy?
5. How does an actor network theory approach help to explain cover cropping adaptation at the watershed and farm level?

Through a case study approach, I am able to more deeply understand how the knowledge production and sharing process compares between farmers who have implemented conservation best practices, such as cover cropping, to those who have not and also explore cover cropping adaptation at the sub-watershed level. Finally, the evaluation of actor network theory tools, mainly in Chapter 6, is in response to the shortcomings of current research tools in environmental studies that derive from innovation diffusion theory.

The present research, then, is significant for four reasons, all of which can add to an ongoing dialogue with researchers and practitioners engaged in sustainable crop production. The research:

1. Identifies the range of existing agricultural knowledges and gaps in knowledge networks in the Vermilion Headwaters sub-watershed;
2. Identifies whether types of knowledge networks affect likelihood of adopting a conservation practice in row-crop farming systems;
3. Contributes to our understanding of planning theory and the role of integrated knowledges; and
4. Advances theory and methods in measurement and depiction of knowledge networks.

Limitations

This study has several limitations. To start, the United States industrial agricultural system is extremely complex and is influenced by multiple interactive internal and external forces that shape farmers' decision-making processes. Suggesting that only one knowledge network type is influential to one conservation practice does not capture the complexity but does illuminate the kinds of knowledges and relationships that need to be fostered. Another limitation is the ability to generalize from the study region to other industrial agricultural settings. Because politics, demographics, and environments vary across the Midwest, my findings may be isolated to this particular area. My hope, though, is that because the farming communities within my study region closely resemble other Midwest locations, this work can translate to other instances in the U.S. Corn Belt. The lack of comparison regions across state lines also opens the door for future studies. I hope, too, that my study can translate beyond planning and agriculture and help to better understand knowledge networks as they relate to practice.

The following dissertation starts with a literature review, then further details my rationale, methodology, including data collection and analysis strategies. Chapter 4 describes the history, landscape, institutional actors, and conservation policies that make up the Vermilion Headwaters sub-watershed and conservation agriculture in the region. Chapter 5 sheds insight on the relationship of knowledge network types experienced by farmers and the degree to which they adopt the practice of cover cropping. It also offers farmer stories, told from interviews, conversations, and observations and ends with generalizations that emerge from these stories when examined collectively. I then further explore the networks in which farmers operate in Chapter 6 and apply two methodological tools drawn from actor network theory and assess the degree to which they help me better understand network formation and relationships. I conclude with a recap of research findings and recommendations for planners, agricultural professionals, and fellow researchers.

Chapter 2 – Literature Review

> "Farmers have found it wise to make what is called a '*rotation of crops*,'—that is, to change the crop raised in a given field from year to year, rather than to raise the same crop year after year. Without rotation, certain fields on the farm would soon become too "poor" to produce good crops, while others would have more plant food than the crop needs" (Goff & Mayne, 1904, p. 50).

In *Principles of Agriculture* published in 1904, Goff and Mayne warned against mono-cropping and encouraged farmers to plant clover as a supplement to the following cash crop. Over a hundred years later, farmers, pressured by national and state policies, economic forces, and climatic variations, are hesitant to heed the call. Although larger structural forces certainly impact farmers on the ground and influence decision making, day-to-day farmer experiences with the land, coupled with farmer interactions with other farmers and ancillary institutions, also have much to say about what farmers actually practice. This latter, post-structural perspective, is what guides my present research. As mentioned, I am concerned with knowledges derived from experiences and interactions in relation to knowledges passed down through scientific, state-sponsored research that can be as influential in promoting and enhancing conservation best practices. Planning, then, is positioned amid this contestation between the myriad knowledge systems that are as much place-based as they are interwoven in broader power dynamics. Empirical research in planning and environmental management suggests the need for contextualizing such knowledges and understanding how knowledge works on the ground and amid overlapping internal and external processes.

In this chapter, I provide more context for cover cropping and explore knowledge literature. I describe my epistemic position and operationalize the knowledge production process, as well as detail the different knowledge network types I employ. I then orient the practice and the process among relevant political ecology and planning theory literature, including pragmatism and symbolic interactionism. This chapter also details actor network theory literature and its methodological link to my research. I then review empirical research and identify methods for characterizing knowledge systems. Finally, I provide a conceptual framework for the present study.

Extent of Cover Cropping

Cover cropping is a conservation strategy that federal and state agriculture agencies have recently promoted in the last decade as a solution to nutrient runoff. Based on conversations with agricultural professionals working with farmers in north central Illinois and across the Corn Belt, cover cropping in the study region has grown in popularity but still lacks widespread adoption. Among the major factors limiting the adaptation of cover cropping in north central Illinois is the colder climate, which prohibits farmers from establishing cover crops in time before first frost hits. However, data from the 2012 US Census of Agriculture indicates that a few counties in Wisconsin are practicing cover crops at much higher average than Livingston and Ford County (roughly 29 percent compared to 1.1 and .57 percent, respectively. The U.S. estimate is at 3 percent for 2012. See Appendix B for map). This discrepancy is due in large part to the sandy soils on hilly terrain that require a cover to prevent erosion (Agricultural Professional 15, personal communication, June 12, 2017). Interestingly, another factor that limits cover crop adoption in north central Illinois is that the area has richer soils compared to other parts of the state and Upper Midwest. Richer soils make it harder for researchers to show improvements in cash crop yields and soil organic matter from cover crops because the soil is already very fertile. Although evidence to the conservation benefits to cover cropping is well tested (Kaspar & Singer, 2011), evidence as to the practice's economic benefits still lacks, resulting in another limiting factor.

As research suggests, the decision to plant cover crops is contingent not only on macro factors but is also highly dependent on on-farm conditions, as well. Furthermore, farming style, experience, and existing social and knowledge networks also influence a farmer's decisions. Conventional, row-crop farmers often get information from fellow farmers first, but also heavily rely on agricultural retailers, such as seed and chemical dealers for pertinent information. Cover crop seed dealers are becoming more common in the region. The University of Illinois Extension is less influential in cover crop research and implementation than other Midwest land grant universities but still play a key role in knowledge dissemination and on-farm experimentation.

Census data and my own conversations with researchers and farmers reveals that cover cropping is gaining traction across the state but is still limited to scattered areas across north central Illinois and is yet to take hold as an accepted practice among farmers. Among the limitations just listed, lack of knowledge in arenas such as soil microbiology appears to hinder adoption as farmers and organizations grapple with the connection between place-based, experiential learning and scientifically verified field research. Even with state-sponsored goals —to address problems of deteriorating soil health and improve cash crop yields—carried out by state agencies like the USDA, Environmental Protection Agency (EPA), and Soil and Water Conservation Districts and agreed upon with farmers, nuances of individual farms and farmer's knowledges make it difficult to standardize and further implement cover cropping.

One problem with cover crop research is that farmers often use the term cover cropping synonymously with other, similar practices. For my study, cover cropping is defined as a cropping system that utilizes "crops grown primarily for the purpose of protecting and improving soil between periods of regular crop production" (Schnepf & Cox 2006, in Arbuckle & Roesch-McNally, 2015, p. 418).

<u>Practice</u>

The Illinois Council on Best Management Practices (CBMP) lists cover cropping as a best management practice mainly for cover crops' benefit to soil health and water quality. Implementation of cover crops is not easy, however, and involves a host of support from institutions (seed and chemical dealers, conservation agencies, and extension services) and other farmers and the farmer's long-term commitment (CBMP, 2016).

Practice is also conceived of through a theoretical lens, which helps to conceptualize the term and makes this study more generalizable. Alasdair MacIntyre in *After Virtue* (1985) defines practice as,

> "Any coherent and complex form of socially established cooperative human activity through which goods internal to that form of activity are realized in the course of trying to achieve those standards of excellence which are appropriate to, and partially definitive of that form of activity, with the result that human powers to achieve excellence, and human conceptions to the ends and goods involved, are systematically extended" (p. 187).

MacIntyre also suggests that to enter into a practice is to enter into a relationship. For example, cover crops purportedly increase crop yields for the following year's crop (or "good"). In the process of farmers working together with others ("cooperative human activity") to improve soil or yields ("standards of excellence"), cover cropping becomes part of a new cropping system (or is "systematically extended"). So too, according to Tamanaha (1997), practices need institutions to sustain them and involve integrated aspects of engaging in a distinct activity (Morales, 1998). In other words, farmer to farmer interaction is not enough to sustain cover cropping, but cover cropping itself (the distinct activity) may bring about an integrated network of institutional supporters. Morales includes in his analysis of Tamanaha's work that practice is "grounded in meaning" and because of this, practices change as different internal meanings change and external actors contribute different meanings. Therefore, networks of actors formed on the basis of knowledge production and exchange affect practice and vice versa. The make-up of individuals and institutions engaging with farmers may well determine what a farmer practices. My discussion on knowledge network types elaborates on how I conceive of different knowledges and network formation.

Knowledge Network Types

Knowledge involves a process (Shin, Holden, & Schmidt, 2001) and is made meaningful only after it is placed within a certain social network (Carolan, 2006b). Sandercock (1998) sums up that "all knowledge is embodied; it is historically situated; it is shaped by language; and it is embedded in power relations" (p. 76). Knowledge is also inherently multiple and involves a variety of actors (Rydin, 2007). Although this research takes up a more post-structural, constructivist epistemology, its ontological position requires a departure from purely socially constructed knowledges, to co-constructed knowledges between peoples, ideas, and things. Actor network theory rejects hierarchical views of the world and also breaks from Western-scientific binarism (Watts & Scales, 2015) making the theory highly controversial, as a socially constructed perspective suggests that "focus of analysis should be on processes that legitimize certain hierarchies of knowledge and power" (Nygren, 1999). Instead, ANT addresses the shortcomings in labeling knowledges as "local" or "scientific" and instead calls for research of hybrid knowledges, particularly in agricultural networks that may be locally situated but globally connected (Watts & Scales, 2015). My research still plays with the classifications of "local" and "scientific" but with an understanding that no knowledge is purely one or the other.

In order to employ actor network theory as a theory and tool to help to identify the significance of hybrid knowledge production (or co-production of knowledges) among emerging and stabilized actor networks, I define and characterize different knowledge networks and describe the knowledge production process.

To start, knowledge is distinguished from opinion, speculation, or information in that it must be "validated against a proof of experience either by an individual or an organization" (Shin et al., 2001, p. 339). Shin et al. next suggest that "knowledge is transferable when individuals and organization share the context" (p. 339). Knowledge *production* occurs when two or more actors within a trusted social network transmit a knowledge claim (Carolan, 2006a). More formally, "knowledge is produced via an iterative process between idea generation brought about by continuous investment in innovation and idea validation through experiential tests of proof" (Shin et al., 2001, p. 346).

A knowledge system, then, arises from the shared experiences and observations of more than one person within a given time frame. Interactions between such systems (or smaller groups of actors) becomes a knowledge network. A network is "a system involving multiple nodes (individuals, agencies and organizations) with multiple linkages—not just informal patterns of interaction, but also structures through which public goods and services are planned, designed, produced and delivered" (Gianatti & Camody, 2007, p. 167). This research focuses on knowledge networks involved in row-crop production. The knowledge system can be configured and characterized in many ways and knowledge networks may comprise multiple systems (see Figure 1, below).

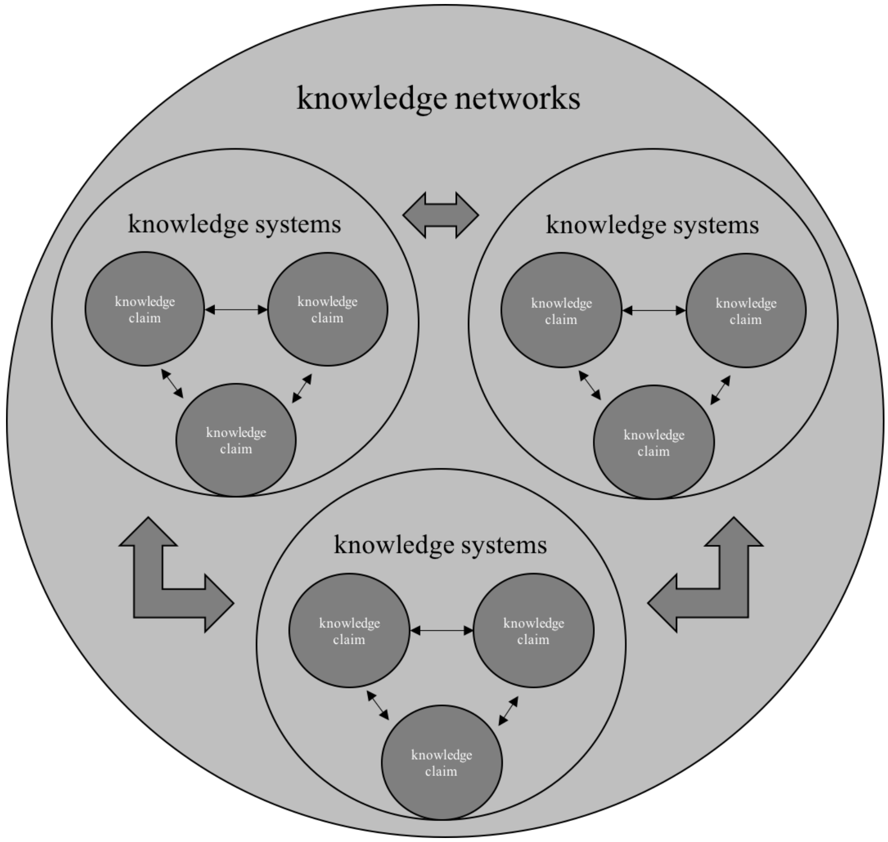

Figure 1. Knowledge Network Comprised of Knowledge Systems

The arrows in between each knowledge claim represent interactions and exchanges between actors. The dark grey circles are the actors who embody knowledges. Knowledge claims come about when an actor has accepted the practice through "proof of experience" (Shin et al., 2001). Interaction among actors with similar knowledge claims, then, make up a group of actors that constitute a knowledge system. The exchange of similar knowledges between systems comprises a knowledge network. It is also important to note that this is all framed within a particular overarching system or actor network, such as a cover cropping system, and takes place at different scales.

The task of identifying different knowledge types in an already complex system is not easy, but much conceptual and empirical research exists on the distinction between knowledges. Here, I offer a brief description of local, scientific, and integrated knowledges. I include how other scholars have explored and classified knowledges and provide a more thorough review later in this chapter. The literature, however, only begins to point to how knowledge networks can be understood amid various actors and institutional frameworks.

Types of Knowledges: Local, Scientific, and Mixed

Local Knowledges. Local knowledges are described in the literature using a variety of alternative terms, including: indigenous, traditional ecological, local ecological, personal, situated, tacit, implicit, experiential, intuitive, and informal (Raymond, Fazey, Reed, Stringer, Robinson, & Evely, 2010). Local knowledge differs from traditional knowledge in that the former derives from a more recent human-environment interaction (a few generations) rather than deeply embedded in cultural practices. Raymond et al. (2010) suggest that local knowledge reflects the understanding of local phenomena.

Scientific Knowledges. Scientific knowledges on the other hand are generated through a formalized process, existing in a written and categorical form that is widely accessible and universally accepted. Furthermore, scientific knowledge is an evidence based, agreed upon process of study, which includes reliability and validity (Raymond et al., 2010). Although I can separately describe these two types of knowledge systems, Watts and Scales (2015) assert that "in the field" both knowledge types tend to hybridize as farmers disrupt idealized models through practice. Some scholars even claim that all knowledge consists of a "heterogeneous blend of knowledges from different sources" and is developed through experience and interactions with a myriad of actors (Raymond et al., 2010, p. 1769). Several farmers in my study area employ field trials at varying levels of formality. Some work with university extension agents and receive compensation, while others set up their own trials. In some cases, farmers work within institutional parameters but cater the trials to their own curiosities and needs.

Mixed Knowledges. The present research adopts the perspective, particularly in the context of agricultural systems, that knowledge networks consist of interacting knowledge systems—that may themselves be characterized as mostly "experiential" or "formalized"—but are all integrated in some way. The task of this research, then, is to unpack and describe the various knowledge claims, systems, and knowledge networks to better understand what knowledge networks exist and how they operate amid planning and farming processes. Attributing types to different networks was done so that I could characterize the knowledge networks, distinguish certain networks from others, and ascertain what outcomes the networks generated. From this review of the concepts of practice and knowledge, following I again lay out the theoretical framework for my study, introduced in Chapter 1.

Planning Theory and Political Ecology

The interplay between cover cropping (as a practice) and knowledge networks (as the interactions among actors immersed in the practice) certainly has its theoretical underpinnings. Traditionally, much of the research on local and integrated knowledge is housed in political ecology (theoretically) and environmental management (practically). Planners, too, have picked up knowledge research, integrating lessons from geography, political ecology, and actor network theory. Political ecology seems best suited for the study of agricultural systems, as its hybrid focus on non-human nature and politics of human struggle allows it to examine biophysical processes, which have no borders, while simultaneously investigating networks created via human and non-human interactions that leverage power and influence (Robbins, 2004, p. 212).

Harrill (1999) grapples with the merging of political ecological thinking and planning theory. He defines political ecology as the “inquiry into the causes and consequences of environmental change, with the goal of facilitating sustainable development through the reconstruction of social and political systems” (p. 67). Harrill suggests that pragmatism, with its emphasis on experiential learning, may be most in line with political ecology, yet stresses that pragmatism needs not to underemphasize power structures that limit democratic participation. He continues, "a theoretical basis for sustainable development in planning can only be found in a philosophical system stressing experiential knowledge of the natural world and human solidarity as expressed through durable social relationships" (p. 72).

My research finds its place mostly within political ecology or environmental management literature, especially with my focus on integrated and local knowledges and agriculture. Yet, my research also has significant implications for planning and planning theory. I borrow from a tradition of pragmatists—in particular, symbolic interactionists—who both are deeply concerned with knowledge and practice. Through my exploration of exactly that, I add to a body of knowledge and theories (some of which are described below) that grapple with how knowledge and practice relate and how planners/planning might contribute to promoting beneficial knowledge work and/or environmentally sound practice.

Pragmatism, Symbolic Interactionism, and Actor Network Theory

Pragmatism. Pragmatism is the basis for knowledge to action. At its foundation, pragmatism understands the world as a continual process with the goal to institutionalize social change (Shalin, 1986). With this in mind, society is seen as both structure and process and within this process comes a blurring of lines between knowledge about things and lived knowledge (Shalin, 1986). In other words, knowledge may derive from institutions, such as universities, but knowledge also is created through everyday experience. The farmer, then, has as much influence in the knowledge production process as does the scientist. Through the implementation of cover crops, knowledge is produced. The process of cover crop production, according to pragmatism, works best if it engages and brings together all *necessary* people with different knowledges. It does not a matter whether a mixture of particular knowledges is included, more that the *right* mixture of knowledges is included to further action.

Furthermore, pragmatism lays the groundwork for an epistemology of practice called "learning by doing" (Sandercock, 1998). Actors possess experiential knowledge formulated via critical actions and interactions with others. Although critics suggest that knowledge in this respect lacks validity in the planning process (Sandercock, 1998; Healey, 2009), “critical pragmatism appreciates multiple and contingent or evolving forms of knowledge, local and scientific” and addresses how knowledge claims reflect structural framing involving power relations (Forester, 2013, p. 6). Borrowing from Forester, my research leans more toward a critical pragmatism that fully deals with everyday practice and also places the practice in a broader structural context. With the help of actor network theory and political ecological thinking, this research has the capacity to also address material or place-based problems, not fully satisfied in critical pragmatism (Harrill, 1999).

Symbolic Interactionism. The present research must also be able to differentiate between meaning, behavior, action, and practice, and symbolic interactionism helps to do so. Arising out of pragmatism, symbolic interactionism focuses more so on face-to-face interactions and is a theory and methodology which seeks to explain human behavior in terms of meaning (Spradley, 1979). With foundations in George Herbert Meade's pragmatism, Herbert Blumer, coined the term and laid out three premises for symbolic interactionism: "human beings act toward things on the basis of the meanings that things have for them…meaning of such things is derived from, or arises out of, the social interaction that one has with one's fellows…meanings are handled in, and modified through, an interpretive process used by the person dealing with the things he encounters" (adapted from Spradley, 1979, p. 6-7).

Habermas, known in part for his work in communicative action theory (also related to pragmatism), finds that action is distinguished from behavior in that it is based on a set of norms and rules. Norms, he suggests, have meaning which justify a certain behavior (Habermas, 1971). More so than the rational planning model and even the participatory model, planners' role here is less concerned with outcome than about understanding the interactive processes that lead to action, including the impact of place.

More specifically related to my research, farmers act based on a variety of contextual factors made up of personal and farm characteristics (e.g., farmer knowledge and agroecology) and broader farming contexts (e.g., knowledge networks, market conditions, and government policies) (Arbuckle & Roesch-McNally, 2015). The authors echo Fishbein and Azjen (2010), stating, "The specific relationships between contextual variables and behaviors thus become empirical questions that can lead to better understanding of the determinants of a particular behavior" (p. 419). My research hones in on the relationship between a farmer's personal knowledges and knowledge networks and what the farmer practices. The practice is a result of human activity or actions, which again are behaviors based on a set of norms. To bring this full circle, the norms are derived from social interactions which generate meaning. Meaning is formed on the basis of perceptions people have of the social world, including policy and aesthetics (Conley, 2011). Perceptions, whether true or not, are necessary to understand in terms of why farmers act the way they do.

Although seemingly similar to innovation diffusion model, which posits that various actors are considered causal to the spread of a practice, pragmatism, in particular symbolic interactionism, gives more weight to the relationships among the actors and the meanings that arise. In this way, symbolic interactionism views the process of innovation as less linear and more self-reflective in that a practice is ever evolving and in itself transforms farmers' actions. For example, farmers work together to implement cover crops, but through the process of implementation, cover cropping changes farmer-to-farmer interactions and this then influences knowledge production.

Actor Network Theory. To go a step further, this research incorporates actor network theory. Actor network theory finds its roots in Machiavellianism but has more recently been made popular by Bruno Latour. Machiavelli originally formulated the idea that instead of dealing with abstract social structures, more so, actors and their relations with others are imperative to understanding social phenomenon (Spinuzzi, 2008). This rather pragmatic approach breaks with classical sociology and is later picked up by Bruno Latour and John Law.

My research contends that actor network theory can contribute to symbolic interactionism and pragmatist planning theory—and also elaborates on Rydin's (2013) assertion that actor network theory is useful to planning practice. As planning theory finds a place for political ecology, so too must political ecology and actor network theory come together. Watts and Scales (2015) call for "a merged political ecology-actor network theory approach to understanding emerging agricultural networks" (p. 233) in that the two frameworks strengthen each other. Although ontological and epistemological differences exist between the two, political ecology and actor network theory may work best together to handle the "liveliness of research on agriculture and human–environment interactions" (p. 233). Having already discussed political ecology in some detail, following I discuss actor network theory's significance to this research.

Simply stated, actor network theory seeks to uncover all conceivably possible reasons behind how something comes to be, or, how does (A) become (B). Actor network theory is concerned with power and is always political and rhetorical (Spinuzzi, 2008). In other words, the theory is interested in mediated negotiations between key actors and embraces material elements—such as texts, transcripts, photographs, soils, climate, and other objects—as methodological tools. An actor is defined as "any element which bends space around itself, makes other elements dependent upon itself and translates their will into a language of its own" (Callon & Latour, 1981, in Schneider, Steiger, Lederman, Fry, & Rist, 2012, p. 245).

One critique is that actor network theory leaves out structural arguments, but Latour suggests that this post-structural ontology allows for a greater understanding of phenomenon through its emphasis of symmetry (Spinuzzi, 2008). Actor network theory shifts the perspective from singular arguments and brings in non-human actors. Spinuzzi (2008) mentions that Latour, along with Callon and Law, finds that all actors are equal and that all actors have an equal possibility in shaping reality. In this way, it is less that broader structures are not influential, only that day-to-day interactions and on-the-ground relationships play as important of a role in transforming practices and landscapes.

As a research tool, actor network theory does not have a set of strict procedures but is more a statement about the nature of the material and social world. That being said, Read and Swarts (2015) detail a research strategy employing elements of actor network theory. To start, the researcher identifies key alliances through ethnographic fieldwork, including interviews, document reviews, and direct observation. Based on conversations with informants and key actors, the researcher identifies what connections are consequential. According to Read (personal communication, December 15, 2016) another important tenet of actor network theory is translation. Translation happens when key actors align. It is important to note that actors align out of self-interest, circumstantially, and actors can align but do not have to agree. Actors work to form alliances through this process of translation, but throughout this process, alliances can also be broken and reformed (Spinuzzi, 2008).

Translation is characterized by four different but sometimes simultaneous moments: problematization, interessement, enrollment, and mobilization. Problematization is the process whereby actors collectively articulate problematic scenarios. Interessement occurs when activities are embraced that are necessary to persuade other actors to accept prescribed roles, which, if done successfully, leads to enrollment. The final step is mobilization in which enrolled actors seek to acquire other alliances. Once the network becomes stabilized through these four moments, it acts as a single entity. Actors can thus be both single entities *and* networks (Schneider et al., 2012).

Actor network theory is also well suited in studying moments of societal shift and provides an analytical edge over existing planning theories (Rydin, 2013). But Rydin suggests that for planning actor network theory is applicable both for planning theory and practice. The author warns, however, that actor network theory is not a practice in actively mapping and forming networks, but rather it is a tool that goes beyond mapping to understand how the networks are formed and stabilized through relationship building and "the role that intermediaries play in bringing actants together and defining their relationships" (Rydin, 2013, p. 31). Through actor network theory, this research can begin to explore the role of intermediaries (planners for one) within the context of developing alternative agricultural practices.

Schneider et al. (2012) and Coughenour (2003) describe actor network theory in depth in relation to the development of no-till farming (another conservation best practice). Schneider et al. emphasize actor network theory as a useful approach to alternative forms of knowledge and stress that little research is underway, particularly in regard to farmers' knowledge. Watts and Scales (2015) echo the need for actor network theory work in agricultural systems research and that actor network theory can offer an alternative perspective. The authors suggest that because actor network theory views actors as fluid and dynamic, research can stay clear of three problematic views of agriculture: 1) a western-scientific view that farmers are passive receivers of knowledge; 2) agriculture is a neo-classical product of capitalism; and 3) a narrow post-structural focus that knowledge is socially constructed.

Most critically, the present research extends the authors' assessment that "a network approach allows researchers to identify the areas of strong and dense linkages that are likely to be most resistant to change and yet afford opportunity for maximum intervention" (Ghose & Pettygrove, 2014, in Watts & Scales, 2015, p. 233). Furthermore, farmers constantly disrupt ideal models developed in field trials, in order to reconstruct farming practices in innovative ways (Coughenour, 2003; Watts & Scales, 2015)—a lesson that is true at times in north central Illinois cover cropping, based on conversations with farmers. Therefore, knowledges (as Corburn also points out) are seemingly co-constructed, not only among farmers and ancillary institutions, but—under the radical perspective of actor network theory—also among soil, seeds, equipment, and climate. Following are more empirical illustrations of knowledge research and its intersection with environmental management practices.

Review of Empirical Research

Given the above discussion on practice, knowledge, and theory, I now turn to empirical research on local and integrated knowledges. Davis and Wagner (2003) examined and critiqued 65 studies—all conducted outside the U.S.—in an effort to systematize methodology of local knowledge research. The authors stress that researchers need to employ a multi-disciplinary, case study approach and that future research must be more explicit in reporting methods. The authors own empirical work finds that identification of knowledge "experts" is a critical initial step in exploring knowledge systems. One way to do this is for researchers to engage with local people who actually utilize the knowledge (Brodt, 2001; Misiko, 2010).

Much of the research to date has been outside the U.S. and primarily focuses on the preservation of local ecological and traditional knowledges within marginalized groups (Berkes, 2012; Brodt, 2001; Misiko, 2010; Olsson & Folke, 2001). A limited number of empirical studies take place in the U.S. (Carolan, 2006a; Carolan, 2006b; Coughenour, 2003), yet the call for local knowledge research in U.S. farming dates as far back as 1991, spurred by the agricultural crises of the 1980s (Kloppenburg, 1991).

Carolan (2006a) employs a case study of 28 farmers and 7 agricultural professionals in Iowa and uses a framework developed by Collins and Evans (2002) to conclude that farmers constantly generate experiential knowledge but lack "interactional" expertise to extend the knowledge to other farmers and researchers. In other words, farmers and scientists lack the language and terminology to engage with each other. Through interviews, the author determines the difficulty in making clear analytical distinctions between various types of knowledge. To overcome this, the author highlights an exceptional case of a farmer who started organic farming at a later age and could more easily articulate when and where certain knowledge was acquired. Although the farmer was able to learn and adapt in a short amount of time, the problem occurred when he wanted to demonstrate his expertise to agricultural scientists. For Carolan, "Future energies would thus be well spent examining ways in which we could nurture interactional expertise, so as to help facilitate knowledge exchange between both local and certified contributory experts" (p. 430).

Raymond et al. (2010) echo the difficulties in categorizing knowledges and suggest that while identifying knowledge types at the outset is useful, researchers should orient relevance of knowledge claims to the problems that need to be addressed. The authors also emphasize the need for the assessment of knowledges within institutional structures. The authors examine three environmental management projects in Australia and determine that projects often fail because different knowledge types are not recognized at the outset, and projects do not find ways to incorporate different ways of knowing.

The above studies address the concerns of a limited mixture of knowledges and the need to provide space for both farmers and outside experts. And although much research exists on farmers' behavior (Reimer & Prokopy, 2014; Thompson, Reimer, & Prokopy, 2015), my research fills the gap on the connection between knowledge networks and farmer behavior. From here, I show how others have used the case study approach and measured knowledges in different contexts but related research.

Methods Used in the Literature

Case study methodology is a strategy of inquiry in which the researcher explores a process or one or more individuals. A case can be bounded by time or activity, and researchers use a variety of data collection procedures over a long period of time (Creswell, 2003). Case studies focus mainly on "a bounded system" or an integrated system, thus are applicable to the study of environmental systems and knowledge systems. The strategy involves full immersion in the setting and rests on a researcher's and participants' perceptions and worldviews (Marshall & Rossman, 2011). The researcher, then, must be aware that his/her own worldview may affect data collection and research outcomes, which can be problematic (Stake, 1995). Case studies can also be hard to generalize beyond the researcher's present case and the selection of a case needs to be well reasoned. Case studies are considered by many researchers to be the most complex strategy, because they can be time consuming depending on the number of cases and the research design. Although troublesome to execute, several researchers, below, offer strategies that avoid such pitfalls. Like other research strategies, methods include interviews, observations, historical and document analysis, and surveys (Marshall & Rossman, 2011).

Several case studies exist that include systematic methods for characterizing knowledges (Berke, 2012; Boschma & Wal, 2007; Brodt, 2001; Davis & Wagner, 2003; Olsson & Folke, 2001). Olsson and Folke explore how knowledge is used in ecosystem management of crayfish populations in Sweden. The authors implement a case study approach of a watershed and employ mainly questionnaires and in-depth interviews. The authors interviewed 10 key informants using open-ended questions to detect local ecological knowledge. Questions centered around perceptions on the circumstances of crayfish populations and reasons of ecosystem change. Conversation with subjects related to management practices and solutions to solving the problems. Ecological knowledge ranged from species behavior and interaction with other species to watershed ecological processes. The authors assert that local ecological knowledge is generated through a combination of experience and scientific knowledge and is not always separate from external sources. The authors created a map to show how local ecological knowledge works in this case at various scales, from crayfish to the watershed level. They also recognize a temporal element of this type of knowledge system. Groups and the larger crayfishing association were formed previous to the study, based on a pooling of people with different knowledge bases. The authors stress that scientific knowledge or external knowledge is very much a part of the process and should not be excluded in the discussion of the development of local ecological knowledge.

Brodt (2001) also addresses specific measurement of knowledges in her analysis of local knowledge in a village in India. Through a systems perspective, Brodt shows that knowledge systems can be placed into hierarchical systems from the knowledge of concrete practices to abstract concepts. In a case study involving multiple ethnographic interviews with villagers, the author identifies different knowledge claims involved in tree management and links each claim (or practice, as Brodt uses the term) to primary and secondary concepts related to that practice. The concepts ranging from human health to religious paradigms are also derived from interviews. This research suggests that external forces and internal meaning inspire certain practices and that knowledge operates at each level.

Using a social network approach Boschma and Wal (2007) study knowledge networks in a case study of footwear districts in Southern Italy. The authors use firms as the unit of analysis and conceive of knowledge networks as the assemblage of firms formed through knowledge relationships. Through structured interviews, the authors measure the intensity of the knowledge relationship, how many and how diverse the relationship, and the degree of geographical openness (local versus non-local sources of knowledge). The authors also pool together firms within a larger district and analyze the degree to which knowledge is generated within and from outside the district. As part of the interview, one technique was to ask firms to recall the names of other enterprises (including other firms, suppliers, and customers) with which they were involved in a knowledge relationship (Boschma & Wal, 2007). In addition, the authors asked to characterize each relationship. Knowledge was then bounded using two categories: market and technical issues. The study finds that many local firms acted in isolation, but the firms that held strong connections to other local firms had better innovative performance. Interestingly, the authors also find that firms have greater innovative capacity when knowledge is also acquired from non-local firms. Concluding, the study called for the need to understand the impact of place on network formation and strength and suggest an in-depth historical analysis is necessary to determine "whether geographical proximity matters or not in innovation processes in clusters" (Boschma & Wal, 2007, p. 197).

This article has tremendous implications for my study in its conception of knowledge networks. I too bound knowledge to technical issues related to cover cropping, which helps divorce knowledge a farmer may have of market trends, which, although important, speak less directly to physical crop production know-how. I also include a historical analysis to give "place" more meaning within my study. Although I use actor network theory instead of social network theory, there does appear to be methodological overlap. One difference is that actor network theory does not give weight to one kind of relationship over another, instead, through the process of analysis, certain influential relationships are revealed.

Applying methods from the above studies in addition to methods drawn from actor network theory allows me to not only measure knowledges, but also the influence of types of knowledge networks in innovation and adaptation of agricultural practices. My specific methods are laid out in Chapter 3. I now turn to my conceptual framework, which explains my understanding of the relationship between knowledge and practice.

Conceptual Framework

From the theoretical and empirical literature on knowledge production, systems, and networks in planning and environmental management, the present study adapts a conceptual framework to orient knowledge networks within the planning and implementation of cover cropping systems across north central Illinois.

First, my conceptual model (Figure 2) highlights the basic relationship between the type of knowledge networks and the likelihood, extent, and rate to which cover cropping is adopted. Simply put, a pragmatic epistemology suggests that interaction shapes what people do, and that interaction inherently produces knowledge. Who interacts with who and/or what and the utilization of emerging knowledges informs the knowledge type and its relationship. The engagement of various actors in a given network informs what farmers on the ground are doing and may affect whether or not a farmer adopts cover cropping and to what extent.

Figure 2. Conceptual Framework

From this model, I expect that farmers involved in a scientific knowledge network are more likely to have a low percentage of cover crops although adaptation may be fast. The low percentage is due to the need to experiment on a small number of acres, and the fast adoption rate is due to the farmer already having the needed technology. On the other end, farmers who mainly engage in local knowledge networks only will have a greater percentage of cover crops because of the smaller acreage of farmland, but adaptation will be slow because of the lack of required technology. Finally, farmers who interact within an integrated knowledge network will employ the greatest amount of cover crops and do so at a much faster rate than the other two network types, due mainly to a more diverse network with the knowledge to successfully implement cover cropping on more acres and with the necessary equipment. Figure 3 represents such assumptions.

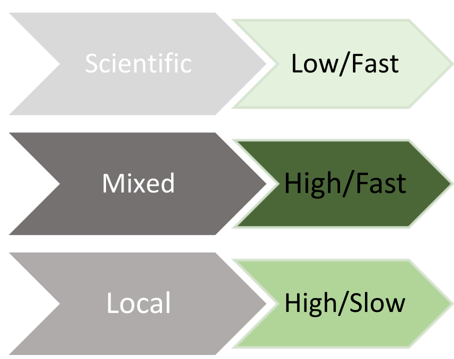

Figure 3. Type of Knowledge Network and Percentage and Speed of Cover Crop Adaptation

A more detailed assessment borrows from Coughenour's (2003) analysis of adaptation to alternative agricultural practices in Western Kentucky. Coughenour suggests that new social networks produce innovative practices. He finds that four key categories are necessary for this framework, including: the policy environment, the supporting network, the farmer, and the farm. My research incorporates elements of this model to fit my exploration of types of knowledge networks and cover cropping. With these as my main two concepts for which I seek to understand, the four categories highlight specific measurable variables that may indicate potential of adaptation of cover cropping at the farmer and sub-watershed level (see Figure 4, below).

Figure 4 lists variables within each category that can help contextualize each category and also helps to identify the particular knowledge network type (scientific, mixed, or local). Exploration of policy documents; interviews with organizations, planners, companies, and farmers; site observations; and attending field visits and meetings allowed me to determine each component.

While the variables help to identify knowledge network type, I also assess whether the farmer and sub-watershed (the Vermilion Headwaters) actually employs cover crops, to what percentage, and the rate at which cover crops were adopted. This is done through interviews and direct observation (again, detailed in the next chapter). Below, I present the conceptual model derived from the literature.

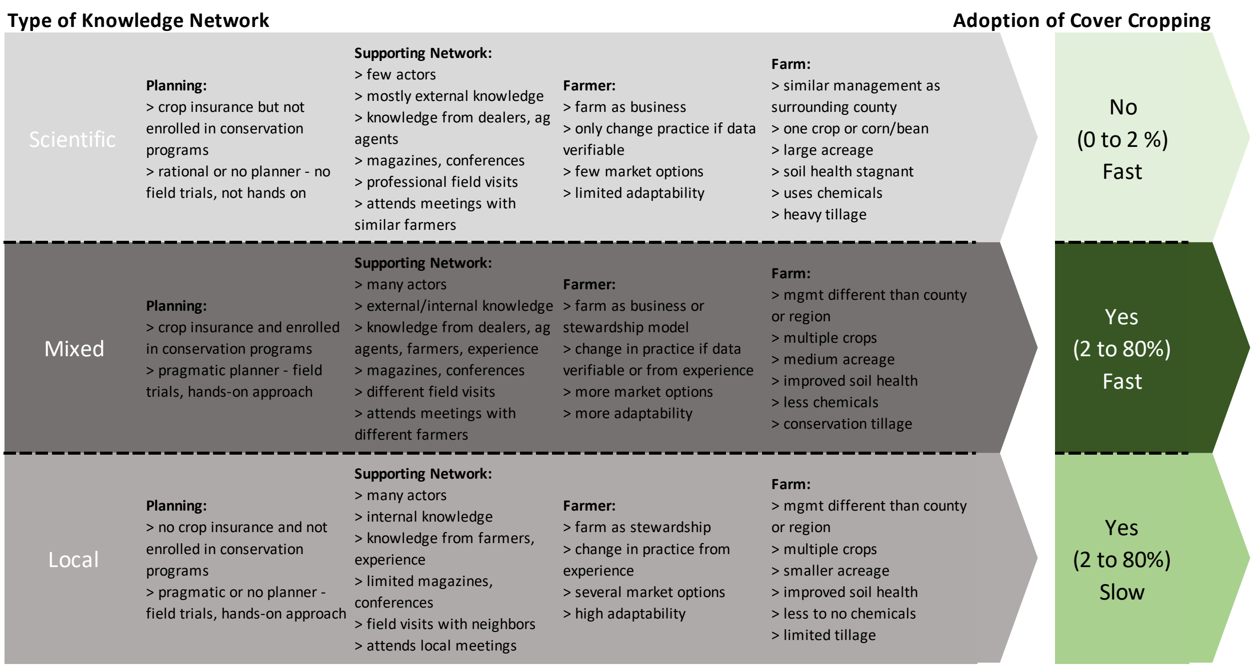

Figure 4. Concept Model Based on Components of the Two Key Concepts: Type of Knowledge Network and Adoption of Cover Cropping

It is necessary, here, to explain the theoretical justifications as to why and how each knowledge network type may lead to a cover cropping adoption outcome. The first reason *why* a certain type of knowledge network may lead to a certain practice is that knowledge networks form based on interaction between people and things. The diversity of interaction generates more diverse knowledges, and therefore, the actors from different backgrounds at different levels in a network are more likely to come up with innovative solutions on how to better grow-crops and reduce the threat to soil health. This means that mixed knowledge networks may offer a wider range of farming strategies and practices, including cover crops. So too, current adaptation of alternative practices relies on multiple actors and farming environments who may not reside in networks of conventional farmers (Coughenour, 2003). In other words, alternative practices involve a different set of human and non-human actors at the policy and farm levels, thus will likely result in different knowledge networks.

Theoretically *how* this relationship between type of knowledge network and adaptation to cover cropping might be the case can best be explained using actor network theory's four moments of translation. First, through problematization, actors identify soil health and water quality problems with cover cropping as a potential solution. Next, actors engage with others to adapt current row-cropping systems to cover cropping practices. This interaction, called interessement, begin the network building process of cover crop farmers. Actors continue to enroll other actors as this new qualitative system is realized. Finally, a broader spread of this network continues through the mobilization phase. Throughout each moment of translation, alliances are formed among actors that solidify and strengthen the network. The make-up of actors (which includes the different attributes in Figure 4) helps to characterize the different types of knowledge and leads to different outcomes.

Research Questions

Out of this conceptual framework, as well as the literature review, come particular questions. Theoretically, I am interested in how planners may engage in practice with other actors and how knowledge networks operating within and through different sets of actors may shape different innovative practices. First, then, I am interested in whether cover cropping as a practice is supported by the state and is indeed occurring in my study region and to what extent. Second, what knowledge systems and types of knowledge networks exist in the study region, and what is the role of planning in influencing knowledge networks. How the revolving narratives of the role of planning (from state-centered to insurgent to pragmatic), explored in both Chapters 1 and 2, intersect with emerging alternative practices is also of interest. Planners operating in multiple political spheres with different actors with different interests may need to find new ways to create alliances with farmers if environmental goals are to be obtained.

Finally, my broader research question combines the above two questions to identify how farmers use and create knowledges to bring about change. I expect that scientific and local knowledge networks lead to less cover cropping, whereas mixed knowledge networks may spur a significantly greater effort in farmer adaptation. In the process of testing this general assumption, I identify new ways to study, measure, and contextualize types of knowledge and explore how this knowledge operates among various actors within adapting cover cropping networks. Chapter 3 describes how I specifically accomplish these tasks.

Chapter 3 – Research Design and Methods

The overarching question that drives my study is: how do farmers, situated in myriad contexts and networks, create and use knowledges to adapt to conservation practices? In the process of answering this question, I seek to better understand the relationship between type of knowledge networks and cover cropping adoption. My research employs a case study approach in the Vermilion Headwaters in north central Illinois, comparing the adoption of cover cropping farmers to non-cover cropping farmers.

The study draws on analysis at two levels: the case study level and the farmer level. For the first level of analysis, I examine a sub-watershed experiencing a greater amount of cover cropping compared to the surrounding region. A sub-watershed level analysis allows me to further assess the involvement of planning and policy, express how place shapes practice and knowledge, as well as validate findings at the farmer level. I focus on one sub-watershed, the Vermilion Headwaters, next to the smaller Indian Creek sub-watershed. Indian Creek was identified in 2010 as a heavy nutrient loading watershed at the outset of the MRBI program, and the Vermilion Headwaters was later identified in 2016 out of the successes of the Indian Creek Project. I talk more about cover crop adaptation in the Vermilion Headwaters and Indian Creek in the subsequent chapters and what sets the latter sub-watershed apart. I also look at the broader study region and two counties to assess the role of planning, on the spectrum of top down or bottom up.

In comparing farmers, I focus on cover cropping at the ground level and the knowledges that may arise from integrating the cropping system. I then examine different actors and networks each farmer is a part of. To do this, I interviewed 13 farmers who have adopted cover cropping, 5 who are undecided but have experimented, and 2 farmers who have not and compare the knowledge network types among farmers within each group. Farmers are not randomly selected as described below.

My research approach utilizes elements of symbolic interactionism and actor network theory methodology. Both help me to tell a detailed history of conservation agriculture in the study region and highlight key actors in the knowledge production and planning processes involved in conservation agriculture. Both methodologies also recognize non-human actors and the meaning actors hold for other actors, suggesting that the ecology and particularities of place inform what people do and what people know. I start this section with a description of my study area, followed by my research questions and how I measure each concept. Data collection and analysis strategies are included, detailing each method, and the variables I analyze. I conclude the chapter with an overview of Chapters 4 through 7.

Study Area

In talking with various agricultural professionals in northern Illinois, I was introduced to Kris Reynolds at the American Farmland Trust. Reynolds serves as the co-lead of the Vermilion Headwaters Watershed Partnership (VHWP). The group was formed out of the successes of the Indian Creek Watershed Project. The Indian Creek and Vermilion Headwaters sub-watersheds are highlighted in the map, Figure 6, below.

My fieldwork took place in southwest Livingston County and northern Ford County in the Vermilion Headwaters sub-watershed (a grouping of 10 smaller watersheds to the southeast in Figure 6, highlighted by the blue, below, also in the map in Figure 5, below) in north central Illinois, which is the lower portion of the larger Vermilion-Illinois River Basin. The center of the Vermilion Headwaters, Chatsworth, Illinois, is located approximately 100 miles southwest of Chicago. The Vermilion Headwaters encompasses 254,322 acres and the waterways flow into the Vermilion River then north on up to the Illinois River and finally to the Mississippi. Some of my fieldwork crossed over into the Vermilion-Wabash River Basin. This watershed flows mainly southeast into the Wabash River and down into the Ohio and later Mississippi River. I draw on the successes of the Indian Creek Watershed Project to show how the two sub-watershed projects combined, push for best management practices. In this way, I am looking at a single case of two separate but annexing watersheds, because the network of farmers and actors is similar, and the Vermilion Headwaters is seen as an extension of the Indian Creek Project.

The region is known for its agriculturally productive soils and is fairly representative of conventional farming landscapes found throughout the Corn Belt. The Vermilion Headwaters, like Illinois and the greater Corn Belt region, is experiencing an increase in cover cropping usage but to a lesser degree. The sub-watershed is selected as a boundary, because farmers' impact on water quality is

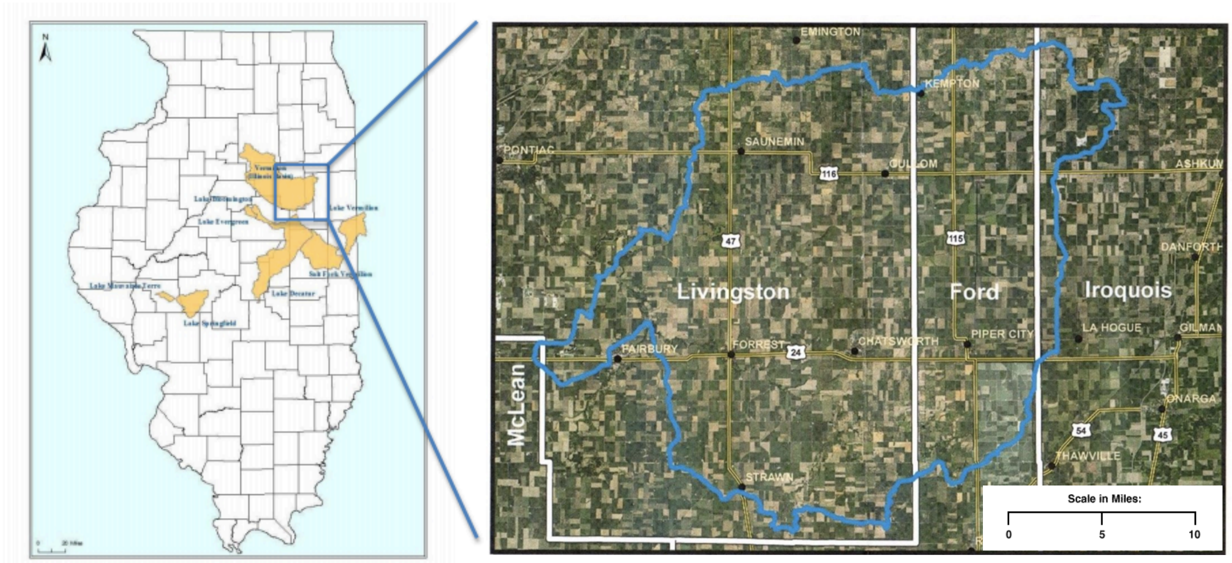

Figure 5. Map of Vermilion Headwaters Sub-Watershed (outlined in blue). (Illinois Council of Best Management Practice, 2011; American Farmland Trust, 2018)

attributed to watershed level decisions and local action, and federal and state policy are often geared toward addressing issues at the watershed level. Counties are selected within this soil region as a way to more easily aggregate agricultural census and demographic data. Counties also host planning bodies and conservation agencies that work directly with farmers.

The study area is of particular interest to answer my research questions, because, unlike southern Wisconsin to the north or central and southern Illinois to the south, north central Illinois has not adapted to cover cropping at quite the same rate. Yet, in response to high amounts of nutrient runoff attributed to agricultural operations, the sub-watershed was highlighted as part of a larger initiative to address runoff concerns in the Mississippi River basin (I explain more in Chapter 4). The proximity to the University of Illinois at Urbana-Champaign (about 50 miles to the south) plays an important role in conservation agriculture adaptation in the region, as well. The university does some work on cover cropping, but I did not come across any cover crop research in my study region. The university does carry out field trials in the watershed related to other conservation strategies. I attended a summer tour that featured a stop at a test plot exploring the benefits of value-added crops next to waterways. Farmers occasionally mentioned

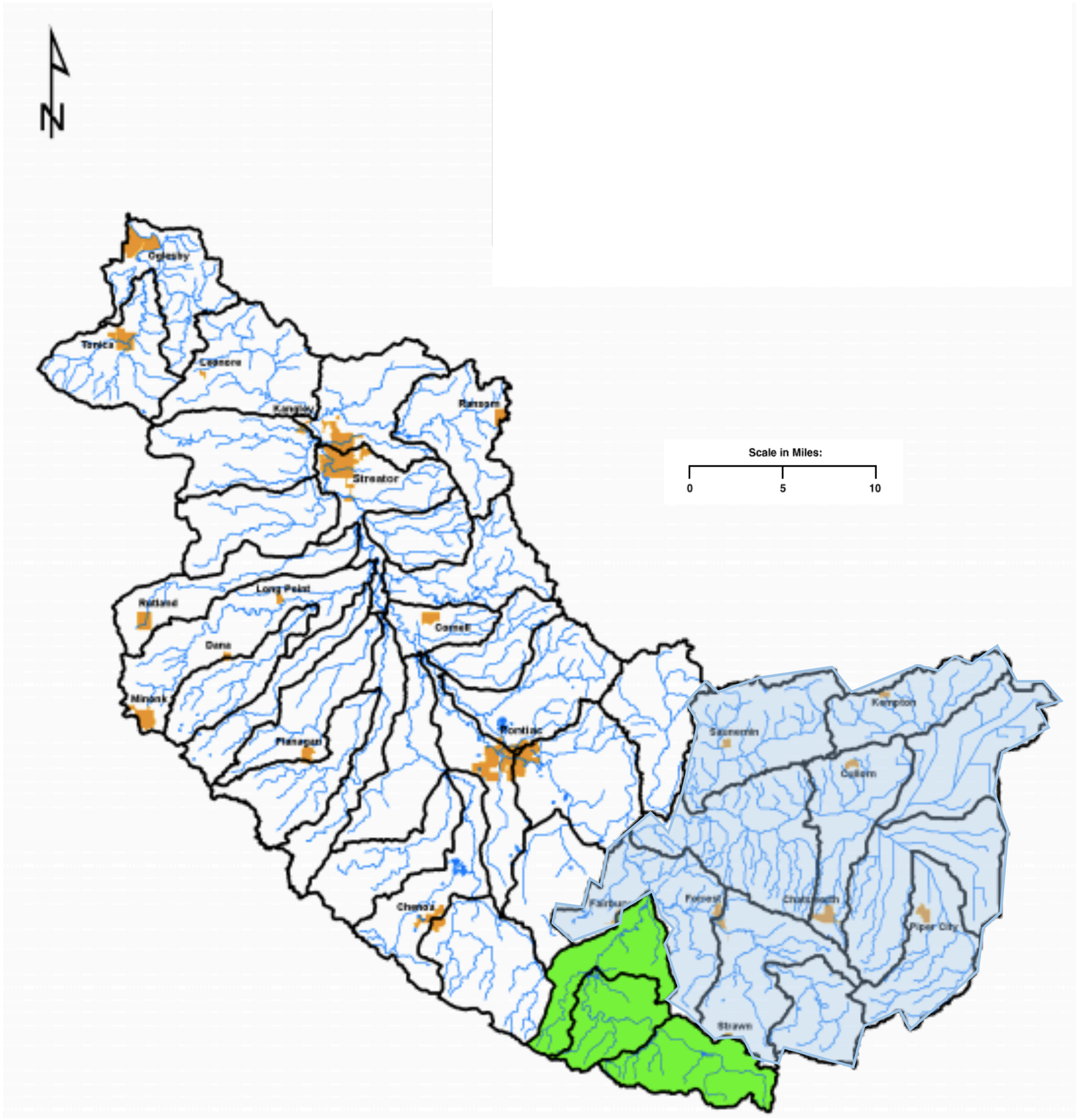

Figure 6. Map of Indian Creek sub-watershed (highlighted in green) and Vermilion Headwaters sub-watershed (highlighted in blue). The entire map is of the Vermilion-Illinois River Basin (NRCS, 2013).

their connections to university folks and will confer with faculty when they have questions. Several farmers also mentioned universities, in general, are a primary source for information on cover cropping and other practices.

Research Strategy

My research questions, again, are:

1. What is the extent of cover cropping?
2. What knowledge systems and knowledge network types are present?
3. What is the relationship between types of knowledge networks and adaptation to cover cropping?
4. To what degree do other factors, beyond knowledge networks, play a role in cover cropping adaptation, including planning institutions and policy?
5. How does an actor network theory approach help to explain cover cropping adaptation at the watershed and farm level?

My overall approach to addressing these questions is as follows: Chapter 4 looks at the extent of cover cropping and what knowledge systems exist within a sub-watershed, including the nature of policies and practices of the state. Chapter 5 explores both the extent of cover cropping and knowledge network types for each of the 20 farmers in my study, examines the relationship of the type of knowledge network experienced by the farmer to whether or not the farmer practices cover cropping, and then offers further analysis based on empirical evidence from coding interviews. I provide summaries of farmer stories in the same chapter for more context. Chapter 6 then brings back in an actor network theory approach, going beyond just the knowledge network, and ties together the previous two chapters to show how farmers operate within a cover cropping network in the Vermilion Headwaters.

In the next section, I include strategies used for measurement of each key concept (cover crops and knowledge networks) and provide an overview of analysis strategies. I describe in detail my data collection and analysis methods in the subsequent section.

Extent of Cover Cropping

I measured the extent of and rate of cover cropping at both the sub-watershed level and farmer level. I only focus on farmers who plant predominantly corn and soybeans. My comparison group is corn and soybean farmers who do not plant cover crops or are undecided. The first step was to identify where cover cropping is occurring within my study area. Although the technical definition of cover crops varies widely depending on who you talk to and in what part of the country, the working definition for my research borrows from Arbuckle and Roesch-McNally (2015), who state, cover cropping is cropping system that includes "crops grown primarily for the purpose of protecting and improving soil between periods of regular crop production (Schnepf and Cox 2006)" (p. 418). Important to note, cover crops must be grown "between periods of regular crop production," "regular" in my case meaning corn and soybean crops or sometimes wheat. This definition does not identify a time, so cover crops, although typically grown in the winter, can also be planted as summer crops between years of growing corn and soybean. Typical cover crop species in my study region include winter cereal rye, spring oats, radishes, annual ryegrass, and clover (MCCC, 2017).

At the aggregate level, a University of Illinois Extension agent suggested I use the 2012 US Census of Agriculture data and, on special request, provided me with cover crop and no-till county-level data. I provide this data in Chapter 4. Acreages of cropland and particular crops are included in Appendix C and also derives from the 2012 US Census of Agriculture. The difficulty with this measurement is that the US Census of Agriculture data relies on self-reporting farmers who may indicate they employ cover cropping, but there is no way to assess from the data whether they intend to use the practice in the future. My inability to map cover cropping at a finer grained did not allow me to unearth as many cover cropping instances as I originally intended. Furthermore, the lack of mapping data makes it more difficult to draw comparisons among relationships of land type to conservation practice.

My method of measuring the extent of cover cropping is shown at the case study area level and at the farmer level.

Case Study Area. In attending Vermilion Headwaters Watershed Partnership meetings, I came across one instance in the larger Vermilion Headwaters, the Indian Creek sub-watershed, that had an exceptional number of farmers adapting conservation best management practices. This is in large part due to the aforementioned Indian Creek Watershed Project that I discuss in more detail in Chapter 4. The Indian Creek Project report indicates the percent of total cropland acreage is at 5 percent for the watershed compared to 1.1 percent in Livingston County (from VHWP steering committee notes, December 6, 2018).

Farmers. The more precise method to measure cover crops I used was to talk with cover cropping and agricultural professionals in the region who pointed me to farmers and areas of high cover crop usage. I then directly asked farmers the percentage of land they have in cover crops and other farmers to talk to (see Appendix E for my interview protocol). I asked farmers to describe their cover cropping system to compare to my definition of cover cropping. I did not find that farmers had mixed definitions of cover cropping as some research indicates.

An important note in comparing cover cropping farmers to non-cover cropping farmers, is that I distinguish between farmers who have fully integrated the practice into their operation to those who have only experimented. Adoption means that they continually plant covers, and they consider cover cropping integral to their overall cropping system. Some of the undecided cover cropping farmers I interviewed have and continue to experiment with covers but have not accepted the practice fully. Asking farmers their thoughts on cover cropping and plans for future cover cropping directly resolved this discrepancy.

Knowledge Network Types

The next step was to explore and identify the various knowledge networks within the broader actor networks. Borrowing from Rydin (2007) and Shin et al. (2001), knowledge is distinguished from information and data in that knowledge is concerned with causal relationships and must be approved through proof of experience. I discussed in-depth my research's epistemological stance in Chapter 2, but to reiterate, I take an actor network theory approach which holds that knowledge is co-created between people, ideas, and things. Knowledge is also made meaningful through social processes (Carolan, 2006b).

I also agree with Rydin that knowledge is inherently multiple, meaning that knowledge has a variety of different sources. Therefore, to study and identify knowledges, I talked with farmers, agricultural professionals, and community and county residents and did so in a number of different settings and formats, including watershed meetings, field days, and farm visits. I limit my study to only knowledge generated and shared around crop production strategies. Crop production involves the planting, cultivating, weeding, fertilizing, pest management, and harvesting of crops.

Case Study Area. At the sub-watershed level, the history and rich description of the Vermilion Headwaters, in addition to the institutional support that includes the actors involved in the Vermilion Headwaters Watershed Partnership and the preceding Indian Creek Watershed Project, expose integral knowledge systems in the conservation agriculture landscape (see Chapter 4). Interactions among farmers, institutional actors, and the physical environment, as well as other knowledge systems then make up the knowledge networks, of which farmers are a part. I represent the actor network of cover cropping in the Vermilion Headwaters in a graphic map and narrative for the Indian Creek Project and Vermilion Headwaters Watershed Partnership in Chapter 6. The map and narrative detail the knowledge sources and systems that constitute the overarching knowledge network, of which the sub-watershed group is a part.

Farmers. Farmers operate within overlapping knowledge networks that consist of smaller knowledge systems, consisting of a set of actors, and specific knowledge claims produced and shared between those actors. A knowledge claim becomes part of a distinguished system through a co-constructed process that is continually testing and retesting assertions and adjusting based on what is happening in the field and what others are saying. A knowledge claim for my research is related to a particular crop management practice (described at the end of the last section). I characterize the knowledge claims based on the source, (e.g., university study, neighboring farmer, intuition, etc.). The knowledge claims make up knowledge systems, consisting of landscapes, institutional support, neighbors, and so on. As mentioned, the interacting knowledge systems form the knowledge network. I classify the knowledge network based on the kinds of knowledge claims and systems they are comprised of. I then attribute each farmer to a dominant knowledge network type (see Chapter 5).

Relationship of Cover Cropping and Knowledge Network Types

After detailing my methods for assessing my two main concepts at both the sub-watershed and farmer level, I next explain how I explore the relationship between the type of knowledge network and the cover cropping outcome. The literature is incomplete as to the make-up of knowledge networks and to what degree each network configuration informs behavior and subsequent practice. The concept model from the Literature Review and later modified based on my empirical work serves as a guide to compare knowledge networks and cover cropping (presented in a lesser version in Chapter 5 and again in Chapter 6). The model aids in determining the degree to which farmers are engaged in certain knowledge systems and how this shapes their knowledge network. For example, I literally went down the list of variables and counted the number of significant actors, identified origins and types of knowledge claims, considered whether the farmer is involved in field days or collaborative programs, and so on.

One simple method I employ to graphically display such relationship is a cross tabulation at the farmer level for the 20 farmers I interviewed (Table 1, below, also in Chapter 5). Each farmer was placed in one of the boxes based on my assessment. I explain how I attributed each knowledge network type to each farmer later in the "Data Analysis" section.

Adopted Cover Cropping?	**Knowledge Network Types**		
	Scientific	Mixed	Experiential
Yes			
Undecided			
No			

Table 1. Sample Cross Tabulation of the Knowledge Network Type and Adoption of Cover Cropping by Farmer

Data Collection

My data collection strategy is guided by my methodological approach, which finds an empirical anchor in human/actor interaction as it relates to on the ground practices. This section lists the specific methods I carried out and when. I include how each method links to my levels of analysis and research questions. I start with a description of preliminary investigations. Next, I explain the use of three heuristics as part of my study and include those in Chapters 4, 5, and 6. The first is a historical narrative in Chapter 4 that involved document review, interviews, site visits, and attendance of watershed meetings. I also provide farmer stories in Chapter 5 that describe adaptation of cover cropping and conservation agriculture from the farmer's perspective. The second heuristic, located in Chapter 6, is a spatio-temporal map and accompanying narrative showcasing the emergence of cover cropping on two farms and within a sub-watershed. The third is a conceptual model of ideal type farmers, also in Chapter 6. All three heuristics, for me, rely on the same data collection methods and thus the process of data collection for the three items were carried out simultaneously. The subsequent "Data Analysis" section provides more detail on how this all came together.

Preliminary Inquiry

The preliminary exploration of my study area was accomplished through informal conversations with first agricultural professionals and then farmers in the region. Throughout the summer and fall 2017, I made phone calls and sent emails to agricultural professionals working in the region. I attended watershed meetings, a field day, and workshops in the study region in an effort to further familiarize myself with the language, practices, and way of life of farmers and the places where they live and work. At the first watershed meeting, I explained my research to the farmers in attendance. This process, what Rossman and Rallis (1998) call "meeting the gatekeepers," provided me with an initial list of farmers to talk to and gave me some legitimacy when approaching other farmers.

Historical Narrative, Farmer Stories, Spatio-Temporal Maps, and Concept Model

The purpose of the historical narrative (see Chapter 4) is to provide context for the emergence of conservation agriculture over time, particularly as it relates to row-crop farming and cover cropping at the watershed level. From this, I pieced together the arrangement of planners and agricultural professionals involved in alternative farming practices and how this has evolved. Doing so allows me to assess what the role of planning is within networks, of which farmers are a part. For the historical narrative, I combed through newspaper clippings and county and municipal historical documents; interviewed farmers, residents and agricultural professionals; visited the watershed; and attended watershed meetings. The historical narrative helps explain the connections of people and place, centered around an emerging alternative agricultural practice in a given watershed.

Based on interviews and personal observations, I drafted individual farmer stories (see Chapter 5), as told from the perspective of the farmer. The stories call out different sources of information farmers use and how they share information, thus serve as a way to verify the knowledge network types of each farmer. They also help to more deeply understand the role of knowledges and knowledge networks and adaption of cover cropping and other conservation agricultural practices. The stories are brief but offer a snap-shot comparison between 17[1] of the 20 interviewed farmers.

The construction of a spatio-temporal map (see Chapter 6) aids in visualizing particular sets of transformations that answer the question: how does (A) become (B)? (Read & Swarts, 2015). For my study, when analyzing the farmer who has adopted cover cropping, (A) is the initial field without covers and (B) is a field that is now planted in covers. For the farmer not using covers, (A) is a field without covers and (B) is a failed cover crop field. The same is true for the sub-watershed level. The map allows me to show the transformation between interacting objects, at both a farm and sub-watershed level. Objects of analysis include documents, artifacts, photos, and words, which are then sorted into associations that display spatial and temporal relations (Read & Swarts, 2015). Smaller narratives accompany each spatiotemporal map as a way to explain the key moments and interactions that led to cover cropping adoption or not. Following, I start with the sub-watershed level data collection strategies and then move to the farmer level.

[1] I exclude 3 farmer stories from the list of 20 because in 2 cases, farmers are related and have too overlapping of stories. The other farmer, I was able to surmise what knowledge network he was a part of, but, due to the nature of the interview, did not get enough of a background story to warrant inclusion in this section.

Data Collection with the Case Study Area (Sub-Watershed) as the Unit of Analysis

I identified the Vermilion Headwaters sub-watershed and smaller Indian Creek sub-watershed as my select geographical area to demonstrate how this area has a greater percentage of cover cropping compared to the surrounding region.

Document Review. I reviewed policy documents from state and federal agricultural policies, mainly the USDA. The policy documents mostly were on conservation programs adopted in the study region that impacted cover crop adoption. I also reviewed programmatic documents related to the current Vermilion Headwaters project and past Indian Creek Project. Documents for the projects were collected at the meetings. I scoured state-level farming news websites to learn more about how policy, conservation practices, market outlooks, and weather conditions affected farmers in Illinois.

Interviews. To assess the role of planning and the planner in different networks, I identified staff at agricultural non-profit organizations, state agencies, agricultural retailers, consultants, university faculty, and other agricultural professionals working in my study region who are involved in conservation agriculture. Planners for my study are considered to be personnel at the government or organizational level who focus on agricultural-related policy formation and land use issues.

Throughout my fieldwork, I interviewed or had conversations with at least one person from each entity that is involved in cover cropping, including: American Farmland Trust; Livingston County Soil and Water Conservation District (SWCD); Ford County SWCD; Natural Resources Conservation Service; University of Illinois Extension; University of Illinois at Urbana-Champaign, Crop Sciences; Soil Health Partnership; Crop Tech Consulting; The Nature Conservancy; The Wetlands Initiative; and the Cissna Park Co-op. For non-farmer interviews, I started by gathering basic information about their work and then honed in on how they may be involved in certain knowledge networks related to cover cropping, in addition to how cover cropping has evolved in the region.

In addition to my own dissertation work, I am part of a larger Humanities Without Walls project at the University of Illinois at Chicago. The project explored how local populations adapt to climate change. My research was one of eight field initiatives across the world. As part of the project, each field initiative was tasked with conducting a two-week long field visit to the site with a project team. My team was comprised of myself as project coordinator, a supervising professor, an MFA student, and a fellow PhD student in English.

The research team visited the Vermilion Headwaters sub-watershed over three long weekends in mid-summer of 2018 for a total of 10 days in the field. The fieldwork allowed me to build off of my initial research through in-depth interviews. Building off of my phone interviews, my team conducted seven in-person interviews with farmers and toured their operations. We also talked to five agricultural professionals, a couple of which gave us a tour of the watershed to start our visit. We also visited a limestone quarry and a remnant tall-grass prairie, in addition to several other activities detailed below.

Field Days and Watershed Meetings. As mentioned, I came across a project co-led by American Farmland Trust and the county SWCD offices that focused on cover cropping in the study region. I attended their meetings, took notes, and was able to find interview participants. I also presented my findings at the final meetings I attended in December 2018.

Data Collection with the Farmer as the Unit of Analysis

Farmers in my study operate on land between 400 and 6,000 acres, with the average farm being about 1,000 acres among the farmers I interviewed. All the farmers are considered row-crop farmers, a few of which also have some livestock. The farmers range from 5 years of experience to 40 plus years, with almost all of them having grown up on a farm or inherited farmland. Even though all have a farming background, they each come with different levels of experience and know-how, especially related to new, innovative practices like cover cropping. Drawing from row-crop farmers who mainly plant corn and soybean makes my research generalizable to the greater Corn Belt of Iowa, Illinois, and Indiana, in regions where similar climatic, environmental, and economic conditions exist.

Interviews. In the summer 2017 to spring 2018, I conducted over 20 phone interviews with farmers and agricultural professionals. Reimer and Prokopy (2014) also interview 20 farmers in in a study on farmer motivations and participation in conservation programs. For the farmer interviews, I asked each farmer similar questions concerning farm information, how they got started on cover cropping, where they got their information, and why they did not cover crop if that was the case. Questions centered around farmers' meaning and perceptions of policies, planning entities, farm inputs, other farmers, etc. This allowed me to draw out meaningful actors within a farmers' network. I also asked about challenges they faced, what they would want to see different, their perspectives on downstream issues, and thoughts on government programs. This follows from a 2015 study on cover crop adoption in the Corn Belt:

> "Farmers who were currently using cover crops were asked to share their views on motivations underlying their decision to adopt, the primary benefits of cover crop use, any challenges that they may have encountered, and the information sources that they use to learn about cover crops. Farmers who were not using cover crops were asked to explain why they did not use them, with a particular focus on perceived barriers and risks" (Arbuckle & Roesch-McNally, 2015, p. 420).

Additionally, I employed an open-ended interview strategy to allow for "people to use their own words in describing their knowledges" and capture important terminology (Brodt, 2001, p. 105).

I talked to 13 cover cropping farmers, 5 farmers who were undecided on whether to adopt cover crops, and 2 non-cover cropping farmers. Although my goal was to have 10 farmers each, finding non-cover crop farmers was difficult due to the lack of access to such a group. Some farmers suggested that it would be hard to find farmers not involved in conservation practices to talk with me for an hour because such farmers do not want to elaborate on their methods or details of their operations and are skeptical of outsiders. Of the undecided and non-cover cropping farmers I talked to, all of them utilize some kind of conservation practice, most commonly no-till or conservation till.

Field Days and Watershed Meetings. Through the VHWP group (described further in Chapter 4), I attended five steering committee meetings, two farmer narrative workshops, and five field tour events. I took extensive notes on what was said and what I observed. The meetings served as a way for me to better understand the technical language of farming and to get to know the farmers. After a couple meetings, they began to see me as a part of what they were doing, and although I explained my research at the first steering committee meeting, many probably are still unsure what I do but have accepted me none-the-less. This allowed me to ask them naïve questions, and they also have pulled me aside on occasion to tell me what book to read next or elaborate on a point made at the meeting. The meetings and events also allowed me the chance to drive around the area and get a better sense of the landscape.

Participatory Observation. In the course of my data collection, I visited the Vermilion Headwaters sub-watershed on 20 separate occasions for various reasons. In the summer 2018, I was able to ride along with a farmer during nitrogen application and later a different farmer during cover crop planting. As mentioned, I also became part of the VHWP steering committee. The observations elicited information that otherwise could not be gathered in an interview or questionnaire. The hands-on experience bettered my understanding of knowledge networks and helped to answer what knowledge networks exist and how they influence knowledge production and practice.

Through the categorization of different knowledge networks, elaborated in the historical narrative, farmer stories, spatiotemporal maps, and concept model using interviews, policy document review, and attending meetings and field days, I suggest not only what knowledge networks exist, but what knowledge network type is associated with each farmer and sub-watershed. My focus is on what networks exist within cover cropping and how this differs from those who practice more conventional cropping systems. I am then able to pull out additional findings from the farmer stories, spatio-temporal maps, and concept model that the initial analysis at the start of Chapter 5 is not able to fully take into account.

Data Analysis

The historical narrative, initial comparison of knowledge network types and cover cropping outcomes, farmer stories, spatiotemporal map, in addition to the conceptual model, require data gathering that I then employed for analysis at both a sub-watershed and farmer level. Here, I provide my formalized step-by-step analytical process.

Throughout the data gathering activities, I recorded the document, person, meeting, and field note I interacted with and where the interview or meeting took place. I transcribed interviews, saved and annotated document materials, and typed up field notes. I organized the data based on time collected and research method employed, as well as organized the data based on who I talked to.

I then coded transcripts and my field notes using ATLAS.ti qualitative analysis software, as well as writing out themes from in-depth interviews and comparing them to ATLAS.ti. Coding was initially based on variables in my detailed conceptual framework, but data also emerged that was inconsistent with my original understanding. A constant back and forth between what arose in the field and themes derived from my own literature review and conceptual framework was important, so that I did not "preclude the opportunity to explore and discover" (Marshall & Rossman, 2011, p. 208). To avoid this, every other month I read through all the data and pulled out general ideas as to what the participants and documents were saying (Creswell, 2004). From this, I came up with alternative categories used for subsequent coding.

Through engagement with the data and coding process, I generated a description for my historical narratives on the history of agriculture in my study area and the emergence of cover cropping, as well as farmer stories. From the narrative and farmer stories, I created themes that serve as findings for my research. Other themes also helped create my spatio-temporal maps and concept model to use, along with narrative representation, for further analysis. Validation of the findings was done through triangulation of information gathered from the different informants. I presented the findings to both farmers and agricultural professionals to make sure what I came up with was accurate.

Employing sub-watershed and farmer level analysis allows me to compare conservation strategies and knowledges among individual farmers separately and across the sub-watershed, as well. Following, I provide my analysis approach for each level, as well as cross-analysis of the two levels.

Extent of Cover Cropping

Case Study Area. The percentage of cover cropping on cropland in the Vermilion Headwaters sub-watershed does not exist. However, talking with agricultural professionals and farmers, I got a sense of the proliferation of conservation agriculture and cover crops in the sub-watershed compared to surrounding regions.

Farmers. Data collection of cover crop and non-cover crop farmers in the region provided me with a set of farmers in the study area. For each farmer, I averaged the percentage of land on which the farmer uses cover crops. I also provide percentage of cover cropping over time on a farm to determine the rate at which a farmer implements covers. Although exact numbers do not exist for this, interview responses hint at when a farmer first experimented and how the practice grew or not.

Cross analysis. Comparing farmers to sub-watersheds, I talked to farmers who are within the sub-watershed and part of the project and farmers who are not. Thus, I not only compare cover crop farmers to non, but also individual farmers to the sub-watershed, to determine whether a watershed group suggests anything about the extent of cover cropping. I compare different farmers' and others' perceptions of cover cropping in different locations within and outside the sub-watershed. Through this comparison, I then draw conclusions about what leads to the adaptation of cover cropping in the study area.

Knowledge Network Types

Case Study Area. I first identified major conservation agriculture and cover cropping agricultural professionals in the region and learned the history of the watershed to understand the key knowledge systems related to cover cropping in the region. The knowledge systems, including the history, landscape, agricultural institutions, and farmers, all contribute to the overarching knowledge network types operating within the sub-watershed. Part of my research question is interested in the position of planners within the array of knowledge networks. Therefore, I paid special attention to planners and agricultural professionals as actors and how they engage in a farmer's and watershed's supporting network.

Farmers. To determine the type of knowledge network, I identified the interacting actors involved in farmer level cover cropping production. Through transcriptions of interviews, I pulled out these actors and how they interact to carry out cover cropping or not. From the transcription as well, I identified key knowledge claims that are passed along to assist farmers with crop practices. Farmers' knowledge claims that aid production were codified based on typologies according to Raymond et al. (2010): local ecological, personal, lay, situated, tacit, implicit, informal, non-expert, expert, explicit, and formal. Each of these types has a definition of which I used as a reference when coding interviews, documents, and notes. Each type also is associated with a knowledge class (what I call type): local, scientific, and integrated. I then compiled key knowledge claims a farmer makes and attributed what knowledge systems a farmer operates among most. An attributed knowledge system was then placed into my conceptual framework along with the other variables to determine the farmer's overall knowledge network type.

Cross Analysis. Knowledge networks, comprised of farmers within and outside of a sub-watershed group, overlap as farmers are included within the sub-watershed. A farmer on their own cannot constitute an entire knowledge network, but s/he does operate within a smaller knowledge system that, with other systems, makes up an overarching knowledge network. Similar to my cover cropping analysis, some farmers I interview are not included in the watershed group. Because of this, I explore the difference between the make-up of a knowledge network between an "isolated" farmer and a farmer who is in a watershed group doing similar practices. I present the spatio-temporal maps and narratives of each of these farmers in Chapter 6, in addition a map and narrative for the sub-watershed and pull out both sub-watershed and farmer level analysis.

In sum, I first identified the extent of cover crops among the sub-watershed and each individual farmer, and then the types of knowledge systems and networks of the same sub-watershed and farmers. Doing so, I compared types of knowledge networks to cover cropping, undecided, and non-cover cropping farmers to suggest, at least within the region, what knowledge network types are most attributed to cover crop farming. From empirical evidence, I pull out additional factors that lead to cover cropping, other than knowledge networks. Going back to actor network theory, I use the spatio-temporal maps which tie together the sub-watershed and farmer story and better illustrate key moments of cover cropping adoption. The concept model present important actors and show the relationship of actors, including knowledges, within the actor network to the cover cropping outcome.

Summary of Remaining Chapters

This present chapter lays out the methods and analysis techniques on which Chapters 4 through 6 discuss the findings. Chapter 4 provides a historical narrative, which draws on document reviews, in-depth interviews with farmers and agricultural professionals, and participant observation. The narrative includes the percentage of cover cropping in the region, where it is most pervasive, and when and how cover cropping emerged. The chapter explores a history of place and practice, documenting conservation agriculture's emergence in the study area. The chapter also discusses the watershed groups most engaged in cover cropping (Vermilion Headwaters and Indian Creek) in more detail. In addition, I provide relevant policy and planning information, as it relates to conservation agriculture and cover cropping.

Chapter 5 identifies the type of knowledge networks among each farmer interviewed and compares this to the degree to which the farmer has adopted cover crops. The chapter then utilizes farmer stories, which show differences of cover crop usage among different row-crop farmers and how knowledges played a factor in adoption. The chapter also recognizes additional patterns as to how cover crops emerge at the farmer level.

Chapter 6 revisits actor network theory and depicts the spatio-temporal maps for a cover crop farmer and undecided-cover crop farmer, as well as a map for the sub-watershed. Each map is accompanied with a brief narrative and walks through the key moments or activities that led to cover crop adoption. Drawing on the spatio-temporal map, I highlight critical interactions, which gives me a better understanding of the link between actors and how knowledges and knowledge networks contribute or not to cover cropping. I then show my conceptual model as adapted from empirical evidence and compare it the concept model from the literature and what I expected to find in terms of knowledge network typologies, those being scientific, local, and mixed, following Raymond et al.'s (2010) classifications. I end the chapter with the usefulness of the spatio-temporal map and conceptual model as two key tools of analysis.

Finally, Chapter 7 makes recommendations for how agricultural-related policy and planning helps or hinders the knowledge production process or contributes to different knowledge networks in promoting alternative agricultural practices.

Chapter 4 – Vermilion Headwaters Sub-Watershed

This chapter examines the myriad actors immersed in conservation agriculture, including the land, the place, institutional frameworks, state policy, and the farmers, with particular focus on the emergence of cover cropping as an adaptation strategy in row-crop farming systems. The chapter takes a deep look at a particular place, the Vermilion Headwaters sub-watershed, and describes the present conditions that make up the row-crop farming landscape. Present conditions make it difficult to implement cover cropping, due to hydrological constraints, lack of land ownership, and colder climates. However, the same hydrological conditions have resulted in federal and state policy formation and garnered support from agricultural institutional actors to collaborate with farmers to adopt cover cropping and other conservation best management practices in the watershed. The farmers, land, and institutional support, then, each become their own set of knowledge systems, working together in the larger conservation agriculture network.

I begin this chapter with a history of land and farming in the region. A historical view allows me to make the network more visible and illustrates how it has come together (Read & Swarts, 2015). I then provide a rich description of key actors and features that make up this landscape and conclude with what conservation agriculture looks like today. Chapter 5 delves into more details on how knowledge networks relate to adaptation and individual farmer’s stories. The subsequent chapter further addresses the relationships of such actors and the network building activities that bring about innovation.

History

The Critical Trends Assessment Program (CTAP), a long-term habitat monitoring program across the state of Illinois, started in 1994 and has since been collecting detailed biological and ecological data across the state. CTAP is sponsored by the Illinois Department of Natural Resources. One of the documents CTAP produced is the *Headwaters Area Assessment, Volume 5,* “Early Accounts of the Ecology of the Headwater Area,” written by John White, who resides in the Ecological Services department in Urbana, Illinois. White draws on early historical writings of explorers, pioneers, and early visitors to describe the ecology of the area.

An early account in 1825 by Chester A. Loomis, a New York merchant and politician, describes the “Grand Prairie” as “level as the surface of a lake” and the soil as “deep and rich, covered with grass and flowers” (White, 1997, p. 3). The soil in the area is mostly deep, black alluvial loam and is comprised of 19 different soil types. Livingston County features one of the thickest coal beds in the state, a major reason for population growth when it was discovered and mined in the 1860s and 70s, although no active coal mines exist today (Liptak, 2016). Limestone deposits are also common. The county features 11 active quarries, one of which I visited during my fieldwork. Limestone is mined and milled not only for building materials but is also converted to agricultural lime or aglime. Aglime is a chalky soil additive composed elementally of calcium and magnesium. The product lowers the acidity level in soils and improves the uptake in plants of major nutrients. Farmers typically spread lime every two years or more.

Loomis goes on to describe parts of the Vermilion River and its tributary streams as rolling and uneven with timber half mile to two miles thick along streams and waterways. Dry prairies featured grasses two feet high, while wet prairies held grasses six to eight feet high. Wild bees were to be found everywhere and wild honey was abundant. He mentions few inhabitants but frequent fields of corn and wheat in open prairie far from timbered land. Back then the land sold for $1.25 an acre (White, 1997).

The first white farmer to Charlotte, near present day Chatsworth in southern Livingston County, arrived in 1857. The later date was due to the immense prairie and lack of timber for fuel. This area was also wet, with large ponds and sloughs later drained by way of a dredge ditch (White, 1997). Other settlers came earlier in 1829 near present day Fairbury along timbered land, now called Indian Grove Township. The name comes from the strong presence of Native Americans in the area. The Kickapoo tribe were located in Indian Grove after settling land disputes with rival tribes. But, when the white settlers arrived, the tribe was moved to what is now Oliver’s Grove, near Chatsworth. The Kickapoo were then removed two years later to west of St. Louis when the United States government took their land at the outset of the Black Hawk War (Liptak, 2016). Today, driving across both Livingston and Ford

Counties in the Vermilion Headwaters, the area south of Fairbury is notable for its diversity of terrain, including oak savanna, and is the most scenic part of the watershed because of this.

Later accounts from Ford County speak of the abundant deer but also beginning in 1855 the emergence of steer and corn. Ford County is also recognizable for being the last county established in the state of Illinois. Farmers told me this is because the county was mostly swamp land and was not suitable for farming, thus unwanted. A map of Ford County shows the northern half as a slender, six-mile in width, arm that reaches up into surrounding counties cut out due to its wet conditions. In White's report, he documents a Ford County farmer with 40,000 acres in 1871, who had a ditching plow 18-feet long that was pulled by 68 oxen. The ditching is what eventually made Ford County a viable spot for agriculture. Still today, if you look on Google Maps north of Piper City, you will see waterways that go in a straight line, indicative of manmade ditches created to haul water off the fields. (I talk more about the hydrology of the landscape later in this chapter, as this is a very important aspect to farming in this region.) What is also remarkable about the Ford County farmer is that he planted 20,000 of 26,000 cultivated acres in corn—small grain and meadow grass making up the rest. This large, monocrop farm seems less the norm moving into the early and mid-20th century, as most farmers I talked to spoke of grandfathers with small acreage and a five-crop rotation.

By 1901, the prairie began to significantly disappear. White references a thesis written that year by a University of Illinois undergrad, who wrote "the growth of the prairie plants is now restricted to the land along fence-rows, roadsides, and railways" (1997, p. 118). The student warns that the more the cultivation, the more prairie species that could become extinct. In 1899, Illinois was number one in the country in corn production with almost 400 million bushels produced that year (USDA, Census of Agriculture Historical Archive, 2019). Last year, Illinois produced 2.2 billion bushels of corn, the fourth highest state production on record (USDA, 2018). In 2016, Livingston County ranked in the top 10 nation-wide in corn (63.4 million bushels) and soybean (16.69 million bushels) production (Grant, February 28, 2017).

During my fieldwork, I collected a *Chicago Tribune* article published in 1975 from the Livingston County Historical Society. The article describes the rising production in corn and soybean in the state and shows a graph of the rising acreage planted in soybean. In 1950, soybeans accounted for 4 million acres statewide but rose to over 9 million in 1973. Corn meanwhile was at just over 8 million acres in 1950 and topped out at 10 million in 1960 but fell to 9 million acres by 1973. Yields that year for the two crops came in at 1.2 billion bushels of corn and 286.6 million bushels of soybean (Orr, September 15, 1975). The article also discusses the unique circumstance of the farmer. Prices for commodities fluctuated, while input costs continued to rise. This predicament still rings true today.

Many of the farmers I talked to come from a long line of farmers. They mentioned their dads and grandfathers farming on much smaller acreage and owning livestock, as well. Only four farmers I interviewed still have livestock. Farmers also mentioned that instead of an only corn and soybean rotation, farmers utilized a five-crop rotation of corn, soybean, wheat, oats, and alfalfa, or sometimes clover. The crops were also more utilized for on-farm livestock feed. A farm record book I discovered at the Livingston County Historical Society, marked 1954, showed a 120-acre farm divided up into five different fields. Four fields were 20 acres in size and were marked as each having a different crop—corn, wheat, clover, and oats. The last section was a 40-acre pasture for livestock.

Fast forward to today and 99 percent of the land cover in both Livingston and Ford County is in agriculture. The average size farm in Ford County is 564 acres and 486 acres in Livingston compared to the state average of 359 acres (US Census of Agriculture, 2012). Ford County has 308,181 acres in farms with corn and soybeans accounting for 93 percent of the acreage. Livingston County is nearly twice the size at 656,275 acres in farms with 91 percent of the acreage in corn and soybeans. Interestingly, 70 percent of the agricultural land in the counties is rented, far above national averages and even Illinois averages. This plays a huge role in what farmers can and cannot do, and I talk more about this later.

Demographically, the population is almost entirely white and skews older, similar to much of the rest of the Corn Belt. The population has declined just about six percent in both counties from 2010 to estimates in 2017. For Livingston County, this is the most negative percent change since the county was established in 1837 (US Census, 2017). Both statistically and anecdotally, the loss in population in this area is widespread—true also in most of rural America—and is particularly impactful for the agricultural sector. Both young and old farmers I talked with lamented the fact that there are not a lot of guys out there wanting to farm. People are either leaving town altogether or finding different work. Much of this can be attributed to the variability and high risks farmers face but also the high costs of land and equipment. A few farmers joked about Chicagoans who come down and think they can start a farm only to realize the immense amount of upfront capital to start and the lack of available and affordable land. In addition, the learning curve is steep for first time farmers who did not grow up farming with their family. This pessimistic outlook plays a big role in conservation agriculture, as farmers are less willing to protect ground that they know they are not passing along to a family member. One farmer told me he doesn't know what he would do if he didn't know his son was right behind him.

Agriculture has served as the basis of development and economy in Livingston and Ford County since white settlers came to this area in the mid-1800s. As the population increased, so did the land turn from prairie to corn and pasture. Following World War II, production intensified across the U.S. and in the Vermilion Headwaters. Farms increased in size and turned to corn and soybean as the major sources of farm income, letting go of land in pasture and diversification in cropping systems. But overproduction had its consequences. Black dirt washed off fields and piled up in roadside ditches. The 1980s Farm Crisis exposed farmers strapped with enormous amounts of debt, leaving them with few options to get back what they put in. Not coincidentally, conservation agriculture in the U.S. begin to emerge at a broader scale following the farm crisis. Conservation tillage practices, popularized as a result of the devastation from the Dust Bowl in the 1930s, began more widespread adoption with high fuel prices in the 1970s and proliferated after the farm crisis. Farmers turned to conservation tillage as a way to cut back on fuel and save resources (Farooq & Siddique, 2015). The Vermilion Headwaters has mainly followed such conservation trends. Later in this chapter, I describe the prevalence of conservation agriculture in the watershed, farmers' perceptions of conservation agriculture, and the dominate models taking shape in the watershed and across the Corn Belt. Before I get into that, I offer an in-depth look at the present conditions of the Vermilion River landscape.

Documenting the Landscape

Similar to William Least Heat-Moon's *PrairyErth.* in which the author traverses over and across an entire Kansas county on foot, I worked with a field team to extensively explore the Vermilion Headwaters sub-watershed and further south in Ford County. We did so on foot, by car, and by tractor. We talked to farmers, conservationists, agronomists, and grain elevator operators. We walked up to giant windmills, climbed down into limestone quarries, walked across remnant prairies, drove through flooded roadways, toured grain elevators, and photographed, took notes on, and collected what we saw, heard, felt, smelled, and tasted. We walked the prairie with a prairie restoration ecologist and documented the variety of plant species. The grain elevator operator we interviewed also runs an agricultural data collection company and owns a drone. He gave us a demonstration during our interview. A conservation specialist had old ceramic drainage tiles (they are now made out of plastic) and let us have one for our records. We also collected Roundup Ready corn and soybeans and post-harvest corn kernels. To top it off, we tried fresh ice-cream from a family-owned dairy farm, located outside of Fairbury. Stella Brown, a member of the field team, documented the work in an artistic piece and accompanying narrative (see Appendix D).

The farmers were kind enough to show us around their farms. Many were happy to drive to various fields to show us something they had experimented with or, in one case, an area that was soon to be a constructed wetland. They showed us mostly fields and fields of corn and soybean but also ditches where they knew water had backed up and spilled over into their field. We saw hedge rows—thickets of Osage orange trees—that had once caught on fire due to a farmer's misjudging the wind. We helped move cattle before an incoming storm. We saw old and new equipment, show pigs, chemical fertilizer bins, and of course cover crops. Although it was midsummer and many of the cover crops had died, cereal rye is a variety that can sometimes survive a farmer's attempt to kill it. Many farmers also invited us into their homes due to the heat, so we sat at their kitchen tables and talked.

Aside from our conversations, much of our time was spent driving. Livingston and Ford are broken up by highways and roadways—each roadway a near-perfect one mile apart. This breaks the landscape up into a grid that separates fields, delineates property lines, serves as a reference for favorable farm ground, and of course offers a line of transportation. None of the roads outside of town have names, only numbers, so one has to know when you switch county lines because the numbers start over again. The vantage point from the road offered a perfect cross section to judge the height and changing color of the corn and soybean fields. We also spotted several fields turned over to conservation land through the Conservation Reserve Program. On occasion, we spotted a wheat field or alfalfa field, not common in the region. We also witnessed a lot of flooded fields. On the first day of our visit, nearly nine inches of rain had fallen the week before and low-lying areas were full of water. Large swaths of soybean fields were damaged and needed to be replanted.

Besides the larger Pontiac, Illinois, where we stayed at a hotel, most towns were under 1,000 people. The small communities served as reference points as we traversed past the fields. Many towns did not have a place to eat or even a gas station but every single one of them had a grain elevator. This is where a farmer takes their grain after harvest or when the grain market is right. The smaller elevators ship their grain to larger elevators or processing facilities not far down the road. The main corn processor in the lower half of the watershed is an ethanol plant, One Earth Energy out of Gibson City in Ford County. For soybean, most farmers go to a soybean oil facility either DuPont in Gibson City or a Brazilian-owned and operated facility, Incobrasa, in Gilman, a few miles west of the Ford County line. The elevators are the tallest structures on the landscape outside the massive windfarms on the northern edge of the watershed.

As part of the documentation, one goal throughout the fieldwork was to identify the major human actors related to cover cropping in the watershed. The Vermilion Headwaters Watershed Partnership (VHWP), described in more detail later, is the lead group responsible for promoting healthy soils and water quality, targeting farmers and land within the watershed. The partnership is comprised of staff members at the American Farmland Trust, the Livingston County Soil and Water Conservation District (SWCD) and the Ford County SWCD, and the county Natural Resources Conservation Service (NRCS) office, as well as a number of farmers, landowners, and community members.

Other human actors, aside from the partnership, include the numerous seed, chemical, and equipment dealers, university extension agents, agronomists, consultants, grain elevator operators, bankers, spouses of farmers, and other family and friends. Interviews with people from each group helped to identify other actors, both human and non, and further revealed actors influential in the emergence of cover cropping in the watershed. Interviews also helped draw out the interactions between actors, what actors are necessary to network building, and the ways in which certain assemblages are enacted, maintained, extended, and transformed (Spinuzzi, 2008).

No formal "planners" exists within this region but both counties have planning commissions—Livingston County Regional Planning Commission and Ford County Planning Commission. These commissions are involved in county zoning and land use issues and impact farming when farmland is turned over to developable land. As of now, pressure from Chicago suburban sprawl does not exist, but windfarm and solar farm development is a highly contested issue. I discuss such development later in this chapter.

Distinguishing Features of the Vermilion Headwaters

Aside from human actors, we came across many more non-human actors that make the Vermilion Headwaters similar to the rest of the Corn Belt but also different. As mentioned, the watershed is 99 percent agricultural with 92 percent of that in corn and soybean. The corn and soybean production contribute to the state's high yield in both cash crops. The size of farms is a bit larger than other areas. The landscape is flat with some rolling hills close to waterways. The roadways follow a grid with large humanmade ditches crisscrossing fields throughout the landscape. The Vermilion River cuts diagonally and flows from southeast to northwest. Several tributaries flow into the main river, including the South Fork, Indian Creek, and the North Fork. A handful of major features distinguish this watershed from others in the Corn Belt. Following, I describe the hydrological characteristics, ownership structure, climate, construction of wind and solar farms, and the presence of a church group.

Hydrology

Of the defining features, hydrology is the most common farmers are quick to mention and the one most readily apparent to the average visitor to the watershed. During my field team's visit in early June 2018, we came across several flooded fields. A few times, we actually had to turn around because the roadways were flooded. Interestingly, we also noticed huge swaths of chopped up cornstalk that lay in piles across the road and on the edges of the field. We first thought this was from the no-till practice but later came to find out this was from vertical tilling. Vertical tillage is a kind of conservation tillage practice that happens in the fall after corn. This practice leaves chopped up corn stalks laying on the field, which creates a cover of sorts over the winter before planting soybean in the spring. The advantage is that corn residue is broken down with less effort than conventional till, which leaves a better seedbed for the next season. The problem, we discovered, is that if the area receives a heavy rain in the spring, the corn stubble can quickly be washed off the field creating large piles of residue. The residue can then suffocate any soybeans that have been planted and also create problems on roadways. Farmers will actually burn this residue when it dries out to get rid of it.

The heavy rain and flooding of fields also causes farmers to have to replant soybeans that have not yet established. Typically, corn is planted earlier in the season, so if the top of the corn is able to reach above the water level, the corn can survive. Soybeans are planted later and tend to have more difficulty if submerged in water. Some farmers are now starting to plant soybean before corn so that it can become better established. Planting time greatly affects cover cropping decisions, such as when and how to terminate the covers before planting. When we visited on June 10, the area had just experienced nine inches of rain in the past week. Farmers consider anything above four-inches to be a heavy rain.

Heavy rains and flooded fields are not so unique to the area. What is remarkable is the hydrological history of the area and continued swamp-like conditions. Much of Ford County was previously swampland and marshes, but efforts by early settlers and continued efforts by farmers throughout the 1900s drained almost all the standing water. To date, however, most fields are still prone to saturated soils. This is crucial as it limits farmers ability to plant in the spring, as farmers need dry, warmer soils to plant. This also greatly affects farmers willingness to try cover crops. If a farmer plants cereal rye, for example, and the crop comes back in the spring, the rye can actually hold too much water even after the farmer sprays it with herbicide to kill it. This concern was mentioned a few times at meetings I attended.

To combat the wet conditions, farmers install drainage tiles 4 feet deep underground at anywhere from 30 to 60 feet increments. The drainage tile is made out of a polyethylene plastic material and is perforated to allow water to seep in. Excess water is piped through the tile and out into a nearby ditch. After a heavy rain, one can see water flowing out of the pipe. Historically, drainage tiles were actually made from clay and placed at much greater distances, often 100 feet apart. Most fields in the watershed have tiling, but the tiles are still very expensive to install. Clay tile still lays under some fields today if it has not been crushed, but most farmers have inserted the new tile. Farmers will even respond to wet areas by strategically placing more tiles in wet areas. One farmer we talked to was considering this option in a particularly wet field. Another farmer who did not have tiling on several fields credited the reason for lower yields to this fact but asserted the high cost of tiles prevented him from installation.

And it is because the proliferation of drainage tiles that this otherwise flat landscape is one of the top five watersheds contributing the most to nitrogen runoff. As water runs through the tiles, so too do the chemicals that are applied most heavily in the fall but also the spring and summer. This excess runoff of nutrients is why there is such a focus on this watershed from institutional actors and such a strong push for cover crops. Cover crops, in particular, work to soak up excess nutrients and store them for the following cash crop. Combined with no-till, which limits soil erosion, cover crops purportedly nearly eliminate soil erosion and add a source of nitrogen to reduce the amount of chemical applicant needed.

Ownership Structure

The second most distinguishing feature of farmland in Livingston and Ford County is the percentage of rented land. In both counties, 70 percent of agricultural land is rented (Agricultural Professional 6, personal communication, May 5, 2017). This is well above national averages and high even for the Corn Belt and rest of Illinois. The main reason rented land is so high in this area is due to a common trend across the Corn Belt of larger farms residing in more productive areas and the high turnover of owned to rented land of aging farmers with no farmer heirs who are forced to rent out their land (Agricultural Professional 6, personal communication, March 11, 2019). The productive land is also more expensive, making ownership less feasible. Many of the landowners are retired farmers, but there is also a large percentage of absentee owners who live in places as far off as California. Although a problem in other parts of the state, there does not seem to be international investment in farmland in this watershed, nor large acquisition of land from large agribusiness companies. However, farmers often enter into commodity contracts with foreign investors and large companies.

Rental leases take two main forms in this region. The most common is cash rent. Cash rent is an agreement between producer and landowner stating that the farmer will pay a certain amount for the land annually with contracts typically ranging from three to five years. Almost all farmers I spoke with who had land over 1,000 acres had a cash rent agreement on a majority of their land. The other form of agreement is a crop share agreement. This arrangement is typically split 50/50 so that the farmer pays 50 percent of the rent and costs to operate but only receives 50 percent of the profit. The benefit to crop share is that the farmer does not have to take on so much upfront costs to operate on this piece of property. Also, if the crop has a down year, the farmer does not take the full blow of the loss. The downside, of course, is that in a good year the farmer will not take in as much profit.

In both a cash rent and crop share agreement, the farmer is at the mercy of the landowner in terms of operation decisions. Often, landowners will want the field to look a certain way and will lay out what a farmer can and cannot do in the rental agreement. Farmers talked about landowners who do not want to see no-till on their field because they do not think it looks clean with the leftover stubble. Other farmers have landowners who encourage cover crops. With cash rent, although the landowner is not on the hook for crop success, they are still judged for what goes on their land. The short-term nature of the lease also means that farmers are less invested in the soil health and quality of the land because they are unsure if the landowner will re-up the lease. One farmer suggested, "As somebody who has done conservation stuff, I want to make the landowner's farm better for them, and I know it can be done. But, when that 30 to 35 dollars an acre extra comes to improve their farm—if I don't know I'm going to farm it in the next few years—I don't know if I'm going to make that investment" (Farmer 10, personal communication, April 6, 2018). Since practices like cover crops often take many years to show improvements to soil health and yields, it is not always advantageous, economically or otherwise, to experiment with different practices.

That being said, many farmers I interviewed talked about having good relationships with their landowners who are willing to experiment—although this is often after a farmer has proven success on another piece of land. Farmers are aware that their reputations precede them and if they are known for being an early adopter some landowners will not rent to them. This changes if a farmer is still able to achieve high yields and showcase a clean looking farm.

The preferred form of landownership is obviously owning the land outright and farmers are quick to tell you this. A few farmers who operate on relatively smaller acreage are thankful for not having to worry about contracts and dealing with landowners. Most farmers own a certain portion and rent the rest, and most owned land at this point is inherited. High costs of land prevent farmers from buying but also makes it hard for young farmers to get a start if they do not have rights to inherited property.

Climate

Another major actor in the assemblage of row crop farming and cover crop adaptation in the watershed is the climate. The weather in north central Illinois is sometimes too cold to plant cover crops in time to get them established before they are winter killed. The further south one goes, the more variety of cover crops farmers can choose from. Planting cover crops ahead of corn is also a challenge. The cover crops can keep moisture in the soil in early spring, which holds in nutrients and water but does not allow the field to dry out and warm up enough to plant.

Many farmers lack the equipment needed to plant covers early, meaning they have less options to choose from. However, farmers in much colder climates, such as parts of Minnesota and Wisconsin, are taking to cover cropping. The phenomenon can partly be explained by either significant topographical differences and combination of sandy soils more conducive to erosion. In other words, cover crops are much more impactful, and farmers are almost obligated to put something on the ground to prevent further erosion. In north central Illinois, the mostly flat landscape dissuades farmers from adopting covers because covers are often promoted as stopping soil erosion. Also, the prevalence of conservation tillage practices in the Vermilion Headwaters addresses any existing erosion issues.

Windfarms and Solar Farms

Among the other distinguishing features are the windfarms that dot the landscape in the northern portion of the watershed. The windmills are a contentious topic in the counties. Prior to the 2018 midterm elections, townhall meetings lasted several hours, as candidates argued for or against the windfarms and residents pitched their claims, as well. Farmers site the carelessness of windfarm companies, who sometimes destroy roadways and drainage tiles without proper repair. The companies switch hands, too, making it difficult for farmers or landowners to make contact. Aesthetically, windfarms disrupt the otherwise open landscape, make a persistent whirring noise when one stands nearby, and also flash red lights at nighttime. The upside is that farmers who allow a windmill to be placed on their farm receive a hefty sum of annual rent. With energy production moving to more renewable sources and large amounts of open space, albeit private property, in the counties, windfarms will continue to be a hot issue among county boards, zoning commissions, and residents.

Solar farms are also a development issue in Livingston County. According to Rebecca Taylor, Resource Conservationist at Livingston County SWCD, solar farms pose less environmental threats than windfarms, a fact confirmed by other agricultural professionals and farmers. For both solar and wind farms, the SWCD is tasked with running a Natural Resource Inventory to assess the ecological impacts of a development. Noise and mechanical movement make windfarms a threat to migratory birds, whereas solar farms do not have these issues. Farmers also talked about the lack of quality control when companies build windmills and have witnessed the windmills catching fire. While suburban development does not quite push into the Vermilion Headwaters, windfarms and solar farms are a major development concern and threaten to take a portion of land from agricultural production.

Apostolic Christian Church

Halfway through our fieldwork, we were told about the Apostolic Christian Church (AC). The AC came up in our talks with an elevator operator. He mentioned that the church is rather influential in parts of Livingston, Ford, and Iroquois County. After we were told about the group, we began to see the evidence. For instance, Fairbury and Forrest, in the heart of the Vermilion Headwaters, both have a large Apostolic Christian church building. To my knowledge, no farmers I talked to attend the church but, when asked about it, they expounded on the influence of the church. AC followers are known for their strong family values and take pride in family owned farms that feature a smaller size and incorporation of livestock. A couple AC families are popular enough to sell their products to Chicago restaurants. The AC folk are also conscientious with money and will not take out big loans or get too involved in government programs.

The Apostolic Christian faith was founded by Samuel Froehlich who broke from the Swiss Reform Church in 1831. The faith arrived in America in 1847, and the followers spread along transit lines to find fertile farmland in the Midwest (Apostolic Church, 2017). While the population of the church is much smaller than it once was, the remnants of the values and faith still show up in traversing the landscape. Most recently, anecdotally we were told that the Church was influential in stopping the windmills from coming in too far south into Livingston County.

The AC values of smaller size farms, incorporation of livestock, and resistance to advanced technology lend themselves to conservation-minded farming practices. Similarly, other Christian denominations in the region adopt a stewardship approach to land management. Farmers sometimes talked about protecting the land that God gave them. Farmers also see the church as a place to talk with neighbors and build community. A farmer’s faith and good standing in the community can be the difference to getting the lease on a plot of land or not. The ties between Christian stewardship and conservation are not unique to this watershed but certainly play a big role in the spread of conservation in the area. Many farmers I talked to suggested that their families have always been interested in conservation and trying out new things. Those who are often among the first to adopt new conservation practices are called early adopters. Farmers usually self-prescribe as early adopters. One farmer put it bluntly to me. He said there are two groups of farmers—those who go out and try new things and those who sit around and have to see what everyone else is doing before they will do something new. According to this logic, the farmers who experiment may advise one another but never make a decision based on what another farmer says. In other words, they do not make decisions based on outside pressures.

The emergence of conservation agriculture in the region, then, seems to be more about localized experimentation and less about widespread adaptation or regulation. Obviously, a farmer has to hear about and learn about a practice to consider trying it. However, adaptation seems to initially occur at an individual or small group scale and does not spread until it has become, as one farmer put it, an "approved practice," meaning it is widely accepted as an industry standard by most agricultural groups. The next section I delve into conservation agriculture in general and how it has evolved in this watershed.

Conservation Agriculture

Conservation agriculture is a term used to describe a set of agricultural management practices to improve the long-term environmental and financial sustainability of the farm. Conservation agriculture differs across regions and throughout the world but relies on three main principles: 1) permanent or semi-permanent soil cover; 2) minimum soil disturbance through tillage; and 3) diverse crop rotation (Cornell University College of Agriculture and Life Science, 2015). In the Vermilion Headwaters, each principle can be attributed to a conservation agriculture practice taking shape in the region. Cover crops help to cover the soil, as does conservation tillage, which leaves crop residue on the ground. No-till or strip-till are two popular conservation tillage methods that require less soil disturbance. The dominant crop rotation is a corn and soybean rotation, although this is not really considered a conservation practice because the farmer is still only utilizing two crops. To diversify, some farmers plant wheat on occasion and/or incorporate cover crops—most commonly cereal rye. Farmers with livestock or who cut hay are likely to grow alfalfa, clover, or other grasses, legumes, and forbs mixes, but incorporating livestock is not typical in this region.

I briefly discussed the extent of cover cropping in this area in Chapter 3. Below, Table 2 and 3 offer more detailed data at the county and much larger Lower Illinois watershed (watershed level data is only available at the six-digit Hydrologic Unit Code level (H071300). The Vermilion-Illinois River Basin is coded H07130002).

Item	Livingston	Ford
Covers	1.1	0.6
No-till	23	24.4
Tile Drained	67	63.7

Table 2. County Practice Rates by Percentage of Total Cropland (2012 US Census of Agriculture)

Item	2012	2007	% Change
Total cropland acres	8,313,354	8,213,457	1.2%
Cropland idle or used for cover crops	317,494	206,925	53%
Percent in cover crops	3.8%	2.5%	52%

Table 3. Lower Illinois Watershed Percentage of Total Cropland in Cover Crops and Percent Change (2012 and 2007 US Census of Agriculture)

Although Livingston and Ford County do not experience high percentages of cover cropping, it is apparent that across the Lower Illinois watershed that cover cropping is on the rise. However, the cover crops number may not be accurate, as “cropland idle” could also be affecting this number. Appendix B shows the percentage of cover crops by county for the entire Upper Midwest.

In terms of no-till, to date, the Vermilion Headwaters is approximately 35 percent no-till (Agricultural Professional 6, personal communication, June 30, 2018), slightly higher than the estimates from the US Census of Agriculture in Table 2. Farmers mainly talk about the evolution of plowing, as such: moldboard plowing, chisel plowing, vertical tillage, no-till/strip-till. Moldboard plowing is the most disruptive to the soil and basically turns over and covers the crop residue entirely. Chisel plowing demands less energy and time and works up about a foot of soil but does not completely turn over the ground. Most farmers in the watershed turned to chisel plowing in the 1980s and some to no-till and modified conservation tillage practices a decade or two later. Cover cropping has witnessed less success. The cost saving benefits are less apparent, even with the support of government programs.

The most popular government-backed conservation programs in the Vermilion Headwaters are the Conservation Stewardship Program (CSP), the Environmental Quality Improvement Program (EQIP), and the Conservation Reserve Program (CRP). Of the 3, the first 2 keep land in production, while CRP takes environmentally sensitive land out of production for 10 to 15 years and sets it aside for farmers to grow species that will improve environmental health. The government leases this land, and the farmer is paid an annual rental fee roughly equal to what they would make on land under production.

CSP allows farmers to select from a menu of conservation practices that best fit into their current operations and to improve conservation across the farm during the contract period. CSP contracts are five years, and farmers are provided an annual payment. EQIP is similar, but farmers are given a direct payment to share the costs for adding, maintaining, or improving conservation practices (NRCS, 2018). The NRCS administers and oversees CSP and EQIP. Each county has an office and farmers are able to reach out to local staff to enroll in the programs. The Farm Service Agency (FSA) administers CRP. Both NRCS and FSA offices are typically housed in the same office with the county's Soil and Water Conservation District. The three entities act as government support to farmers for loans, financial services, and technical support, as well as the county's land use planning needs.

In the Vermilion Headwaters, many farmers I talked to suggest that they would not experiment with cover cropping if it were not for this support. A few, however, have decided not to enroll in any programs due to programmatic constraints, lack of flexibility, and the hefty amount of paper work. A growing sentiment among all farmers is the fear of regulation. Agricultural professional's even pitch this as a reason to get ahead of the curb and into cover cropping, Due to the myriad of programs, options for conservation practices, and financial and technical complications, farmers often rely on a network of people to help them navigate and successfully incorporate these different practices into their operations. Farmers rely on fellow farmers, neighbors, advisors, and will also attend meetings, conferences, and get involved in local groups focused on various farm-related issues. One such group in this watershed is the Vermilion Headwaters Watershed Partnership.

Vermilion Headwaters Watershed Partnership

The Vermilion Headwaters Watershed Partnership (VHWP) was formed in 2016 based on the successes of the Indian Creek Watershed Project, which started in 2010. The Indian Creek Watershed Project, located in a sub-watershed of the Vermilion-Illinois River Basin, was an effort led by the local SWCD, NRCS, and the Conservation Information Technology Center (CTIC) to address local water quality concerns, which in turn affect excess nitrate loading in the Mississippi River Basin. The USDA established the Mississippi River Basin Healthy Waters Initiative (MRBI) in 2009 to address nitrate loading issues. The MRBI came out of a call from the USDA for states to adopt individual nutrient reduction strategies. The Illinois EPA adopted the Illinois Nutrient Loss Reduction Strategy (NLRS) in 2009 and the document still serves as a benchmark for policy and project goals.

The MRBI spans across 13 states and uses Farm Bill programs, such as EQIP, to help farmers protect water resources through voluntary conservation actions. The goal is to reduce the flow of nitrogen and phosphorus into the surface waters and down into the Gulf of Mexico. The MRBI supports the NLRS through a small watershed approach. In 2018, the MRBI funded 32 watersheds, 1 of which is the Vermilion Headwaters, with an additional 24 watersheds added this year (NRCS, 2018) (See Vermilion Headwaters map below, Figure 7).

The VHWP is funded through the MRBI and is led by the American Farmland Trust, Livingston County SWCD, and the Ford County SWCD, with support from the Livingston County NRCS Field Office. The team is tasked with providing information and resources on best practices and incentives for farmers who may want to adopt conservation practices, such as conventional till, cover cropping, and constructed wetlands to reduce runoff and improve water quality. The VHWP meets quarterly as a steering committee with the lead team and resident farmers and also hosts farm tours to showcase field trials of different conservation practices. Cover crops are heavily promoted because they can potentially provide up to 30 percent nutrient loss reduction (Iowa Nutrient Reduction Strategy, 2013), although several farmers I talked to refute this claim.

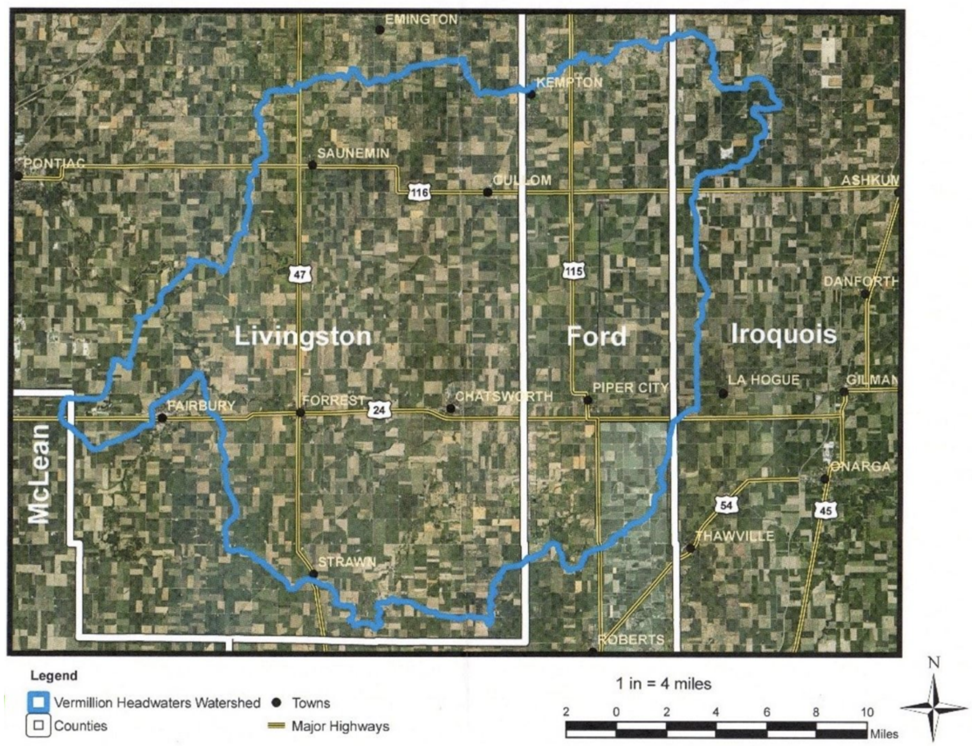

Figure 7. Map of Vermilion Headwaters Sub-Watershed (American Farmland Trust, 2018)

The Indian Creek Watershed Project focused on a much smaller watershed area (51,243 acres) that is also part of the larger Vermilion-Illinois River Basin. Several of the farmers I talked to mentioned that their success with cover crops was largely in part to the Indian Creek Watershed Project. CTIC published a brochure on the successes of the project. The brochure highlights several key points, among which are building off a community spirit and having a diverse steering committee (CTIC, 2018). Partners at the VHWP often talk about the smaller size of the Indian Creek Watershed Project being one of the main reasons why it worked so well. Many partners think that the larger Vermilion Headwaters area makes it more difficult to build a network of trusted stakeholders and collect adequate data. I discuss the successes of the project in more detail in Chapter 6.

As mentioned, out of the VHWP, I met several farmers whom I later interviewed and some of which I toured their farms. To conclude my fieldwork and data collection process, I hosted a farm dinner in November 2018. This allowed me to triangulate and verify my findings, but I was also able to ask further questions I still had related to conservation agriculture. Below is a recap of the dinner and more perspective on conservation agriculture in the Vermilion Headwaters, as told by the farmers.

Farmers' Perspectives of Conservation Agriculture

In early November 2018, I hosted a farm dinner with my fieldwork partner, Stella Brown. I invited all the farmers who I conducted in-depth interviews with, in addition to the agricultural professionals. In all, six farmers attended, one agricultural professional, three farmers' spouses, and one farmer's son. Stella and I made entrees for the farmers. The guests arrived at 6:00 PM, and we had dinner. I then presented my research findings and asked for feedback. I concluded the evening with an activity asking guests about conservation agriculture in the past, present, and future.

The dinner was intended to triangulate my research findings but also was a chance for me to dig deeper on farmers' and their families' perspectives on cover cropping and conservation agriculture. The activity asked the guests to write a word or phrase on post-it notes that best captured conservation agriculture in the Vermilion Headwaters in the past, present, and future. The guests responded to each time period for each post-it note and could write several responses for each post-it note. The wives also participated. Below are their responses (Table 4).

Past	Present	Future
Clean	Technology	Small grains
More rotations	Less tillage	Diverse markets
Small farms	Beginning use of cover crops	Regulated
Tree lines for fence	Filter strips along streams	Growing food more locally
Was there but not thought about	Spoon feeding nutrients	All depends on voters
More fertilizer/chemicals	Data	Educating everyone on issues
Changing landscape	Proactive efforts but sporadic	?
Less tillage but more chemicals	Independent, economically driven	Regulation increases due to ineffectiveness of volunteerism
Farming was more basic	No till	Sustainable
Conservation was a luxury	Strip till	Positive voluntary participation
More profit oriented	Side dressing	Cover crops on more acreage
Smaller operations	Cover crops	Not farming on damaged land
Many families	Soil testing to best use fertilizers	Only applying needed nutrients
Farming was life	Crop rotation	Less tillage
Food source for family	Use of nitrogen	Cover crops
No crop rotation	Partnerships	Additional nutr. mgmt. practices
One machine	Technological advancement	Will learn from past
Less land for farming	Science took over, education	Look at pre-farmed ecosystems
Less access to chemicals	Money driven	Government mandated programs
Lower demand	Providing food for world but not families	More responsible use of resources
Local markets	Starting to develop conservation	More cover crops used
Natural conservation practices	Replaced with efficiency	More no-till and strip-till
Plowing	No-till practices	Technological advancement
Working ground multiple times	Nitrogen management	More robotics
More fences and wildlife habitat	Trashy	
Hedgerows	Less rotation	
Small farms	Large farms	
More crops in rotation	No tree lines for fence	
More diverse farms	Coming into its own	
Small farms with diversity	Looking to future for land health	
Nutrient cycling		
Smaller acreage		

Table 4. Farm Dinner Activity Responses (Personal Observation, November 10, 2018)

After guests wrote down their responses, I collected all the post-it notes and laid them out in a group for each category. Guests then walked past and viewed all the notes. I then asked for feedback on what stood out to them about others' responses. The guests talked mainly about the varying size of the farm operations, future regulation, and the lack of young farmers. Among the biggest threats to a farmers' way-of-life is the potential for extreme regulation. Farmers often reference Chesapeake Bay and the heavy regulations placed on farmers in that region. One farmer at the dinner said that he did not want to be told exactly what to do on his field. This led to a discussion about the role of the government in providing more flexible options for farmers with different needs. Another big concern is that as farmers die off and do not have someone to pass their land on to, land will be absorbed into other operations, making farm acreage larger and larger—the result being fewer farmers to manage larger farms. While this does not discount the potential for widespread cover cropping and other conservation practices, the larger the farm acreage, the more useful and efficient automation becomes. This means that cover cropping may have to adapt to this kind of automation if it is adopted at a large scale.

In my analysis of the responses I see a trend toward what I discuss in the next section. Farmers are taking two approaches to the future of conservation agriculture. The first is the technologically advanced, highly subsidized and mandated operation. The second is the return to diverse cropping systems with voluntary participation. A farmer actually came up to me after the dinner and said that he sees two routes. One being that farmers continue on the current trajectory, turning to science and technology for solutions and direction. The other being that farmers rely more on small grains, heavy rotation, and find diverse markets for value-added products. Both can include cover cropping, but the latter *requires* some kind of cover crop as part of the rotation. Although, the trend towards larger farms does not bode well for the full integration of this type of farming, the future will probably make space for an overlap of the two. I discuss in detail the two models for conservation agriculture in the next section.

Competing Models in Conservation Agriculture

Even before the farm dinner I became aware of the split in conservation agriculture, and really agriculture at large, between precision agriculture and regenerative agriculture. Precision agriculture was a term I came across in my preliminary research but usually saw it in studies taking place in Europe. In my fieldwork, however, I met a farmer who worked for Precision Conservation Management and also stumbled upon Precision Planting's new research farm in Pontiac, Illinois. Analysis of the interview transcripts also reveals watershed farmers' adherence to the tenets of precision agriculture.

I was first introduced to regenerative agriculture by Dr. Adam Davis, a weed scientist at the University of Illinois at Urbana-Champaign. He described a regenerative system simply as one that uses crop system diversity in a way that allows for environmental resilience. Using the right cropping systems, such as certain cover crops, can allow for weed suppression without relying on herbicides to do all the work. A diversified system often includes small grains, like oats and barley, that can be harvested as a commodity. Few farmers in my study followed this model, but many alluded to it as an optimal way to farm and also mentioned that this was how their dads farmed. Following, I lay out each model and add what farmers said about the model.

Precision Agriculture

Precision agriculture is a model that fits in most neatly with conventional and some conservation-minded farming systems. The model relies heavily on technology to address bio-physical constraints and collect and analyze data to aid in decision making. Speaking to a farmer in the business, he said that precision agriculture "often includes a global positioning system to look at spatially what's happening on the field or farm and then fine tuning based on that" (Farmer 4, personal communication, January 25, 2018).

Precision agriculture usually requires purchasing or leasing up-to-date equipment that purports to save time and labor costs and is more energy efficient, especially at a larger scale. Such model, then, is typically more useful for larger producers. Precision agriculture relies on an abundance of field trials to test products and techniques. Precision Planting's research farm consists of "50 active test plots on 200 acres" measuring anything from fertilizers on strip-till corn to the orientation of the corn kernel when planted (Precision Planting, 2018; personal observation, July 15, 2018). A farmer doing a field trial in Livingston County this summer mentioned Precision Planting's "SmartFirmer" product as useful in assessing soil moisture content, a determining factor in crop yield. From the company's website in response to a typical farmer's early season questioning on field conditions:

> "With SmartFirmer you no longer have to guess. Put eyes inside every furrow with a seed-firmer sensor that measures organic matter, moisture, residue and temperature. Now you can optimize hybrid selection, population, depth, fertility and row cleaners in real time… Soil moisture is a critical component for seed germination and uniform plant emergence, and ultimately crop yield. SmartFirmer gives you row-by-row visibility to soil moisture in the seed furrow, allowing you to choose the right planting depth as soil conditions change" (Precision Planting, 2018).

This type of technology is not cheap. A single smart firmer alone is $475, and one smart firmer is needed per 4 rows. Some farmers I talked to have 24-row planters, which would equal $2,850 for one tractor. The cost is what detracts a lot of farmers from incorporating this type of technology, yet many farmers would be eager to have access to this type of information.

In the case of the watershed, a handful of farmers I talked to work with a well-respected consultant whose company is based nearby. The company, Crop Tech Consulting (CTC), conducts over 150 test plots every year and gathers research data on equipment and practices (CTC, 2018). Farmers can offset costs of buying their own equipment, as CTC gathers yield mapping, soil testing, disease monitoring, and other information and works one-on-one with the farmer to adjust farming management strategies and techniques. Almost all farmers will work with some kind of advisor to acquire and decipher data, from a university extension agent to a seed dealer to a private consultant, and most often with all of these groups. The high-resolution data and efficient technology can help a farmer to address conservation concerns by reducing chemical inputs, boosting soil organic matter, and decreasing nutrient runoff. Surprisingly, some farmers have their own drones to capture data and many utilize drone services. Drones, among other things, can detect where in the field there is a deficiency of nutrients, and farmers can then target their applications to that spot instead of wasting nutrients where they are not needed.

Regenerative Agriculture

Regenerative agriculture as a term has been around for some time but recently has been popularized by Dr. David Montgomery in his book *Growing a Revolution: Bringing Our Soil Back to Life* (2017). A couple farmers mentioned the author to me before I had ever heard of regenerative agriculture because of his take on the importance of soil to our survival. Montgomery spells out the three main components of regenerative agriculture in his book: using cover crops, complex crop rotation, and no tilling. These tenets mirror those of conservation agriculture in general. The former model, however, is focused more on building soil health as the primary goal of farming. Other names for the model are biological farming and agroecology.

A post from the Center for Sustainable Agriculture and Natural Resources at Washington State University by faculty Andrew McGuire (April 4, 2018) neatly sums up the model as an amalgamation of conservation agriculture, enhanced biodiversity, and sometimes adding elements of grazing and organic farming. Interestingly, the claims made by proponents of regenerative agriculture and its replicability across climates and soil types are heavily critiqued and often refuted. The post garnered 74 comments as of December 10, 2018, many opposing the author's critiques of the claims made about regenerative agriculture. There is some discussion on the incorporation of livestock in all systems and whether this might work if soil compaction is an issue. Gabe Brown, the leading proponent of this model and famous livestock farmer from North Dakota, comments several times. The author argues that extraordinary evidence is needed for the claims being made by Brown and others, meaning peer-reviewed publications in scientific journals. Brown then states in the comments that "most research coming out of our institutions today is meaningless to producers" (McGuire, April 4, 2018).

The relevancy of the tenets of the regenerative agriculture model are also debated in the Vermilion Headwaters. Farmers may try out strip-tilling, but the on-farm soil type and hillier terrain causes the strips to wash out making cover crops difficult to plant. Less-hillier ground with better soil types nearby may produce a much different outcome. One farmer I talked to stated,

> "Quite honestly, and I think most people know, it's the subtleties that are practiced that make it difficult. So, any of these practices, like no-till, have a lot of variation about how you do it. It depends on other things like drainage. It's good on a drained field but terrible on an undrained field. There's other factors that make it not as simple as these articles and magazines would have you believe" (Farmer 3, personal communication, January 6, 2018).

Not only is each practice difficult to manage on each plot of land, the conservation practices will sometimes negate others, as well. For example, if a farmer practices no-till to reduce soil erosion, there is no sense to them to also practice cover cropping to do the same thing. Even if covers may add nutrients, losing one of the advantages can make it less valuable to the farmer.

The back and forth about the merits of regenerative agriculture is fascinating. In talking with Dr. Davis and listening to Dr. Montgomery, it seems that this model, like conservation agriculture in general, is less about a wholesale adoption of every conservation practice and more about a slow transformation from an intensive monocrop system to a more diverse system with less chemical inputs and soil disturbance. Dr. Davis also talks about growing value added crops to diversify a farmer's income. Several of the farmers I talked to support the idea of adding value to what they grow. One farmer grows a certain variety of food grade, non-GMO soybean for a particular Japanese market. Another farmer grows corn for Frito-Lays. Both fetch higher prices at the elevators than standard commodity crops.

Summary of Chapter

Whether via precision agriculture or a regenerative approach, conservation agriculture overall is witnessing an uptick in farmer adaptation in the Vermilion Headwaters. Increasing heavy rain events, record-low commodity prices, and perceptions to impending government regulation are some of the main drivers. So too are the efforts put forth by state-sponsored institutional actors, such as local SWCDs, the NRCS, and university extension agents. Other institutional support from agricultural non-profits, consultants, and retailers also exists. Historically, intensive agricultural production has ripped the prairie from the rich soils it created. Advances in technology have cleared the way for extremely high productivity in once swampy, agriculturally undesirable landscapes, but not without consequences. Many farmers, steeped in a particular place, noticed subtle and sometimes more abrupt transformations of the land, affecting the ecology and economy of the watershed. Calls to conservation, backed by government policies, often failed to adhere to local contexts.

Recently, however, agricultural experts and conservation groups, made up of the institutional actors, just listed, are working more directly with farmers in an attempt to cater projects to watershed and farmer level needs. Such actors also come with more place-based knowledges and rely as much on the farmer in order to take into account on-farm conditions.

Cover cropping, while adding environmental benefits, is more difficult to adopt due to added implement and equipment costs. Much information exists on the practice, but more extensive knowledge and experimentation on-farm and in local watersheds is needed to garner more widespread support. Precision agriculture offers technologically-backed solutions and may well-serve as an approach one approach to integrating cover crops into existing conventional cropping systems. Regenerative agriculture calls for a greater transformation through incremental change and sees cover cropping as just one major tenet.

State-sponsored programs continue to promote conservation practices with a top down approach, on the whole, but recently, there is some movement to a more grounded approach. Even still, some farmers adopt cover cropping, and some do not. This indicates a need to understand the role of type of knowledge networks as a possible way for the state to improve conservation practice adoption. The next chapter compares the knowledge network types in which each farmer is a part to individual farmer cover cropping outcomes. The following chapter takes a closer look at watershed and farmer level network building.

Chapter 5 – Farmer Stories

The last chapter described the set of actors and knowledge systems—histories, land, and institutional support—operating within the Vermilion Headwaters watershed and offered an in-depth depiction of the landscape from my own account and that of farmers and agricultural professionals. In sum, conservation agriculture seeks to curb the ill-effects of intensive farming, and cover cropping is widely championed by conservation groups as a best management practice that can provide ecological benefits and add biodiversity to enhance the soil. Cover cropping, as an innovative practice, can also "serve as a gateway to doing other conservation related practices" (Agricultural Professional 11 & Farmer 13, personal communication, July 13, 2018). But to many farmers, cover cropping cannot be considered an isolated endeavor. One farmer spoke up when I presented my findings at a steering committee meeting, suggesting that covers have to be considered a part of an "entire system."

A farmer's experience with a cropping system varies from farmer to farmer, depending on a host of management decisions and on-farm conditions. Figuring out whether a new practice, like cover cropping, is right for their particular system—within the broader network of market, climate, people, information, and on farm conditions in which they operate—often takes years. And, within those years of data gathering, knowledge sharing, experimentation, and trial and error, the network continues to change. A farmer's cropping system is part of what I am calling an actor network and is comprised of overlapping knowledge systems and supporting human networks. Farmers in a particular watershed are often operating within similar actor networks and knowledge networks.

This chapter explores how such knowledges come to affect innovating cropping system practices. I first relate the knowledge network types of individual farmers in my study to their cover cropping outcomes and then look for other patterns that emerge from coding interviews. Both of these require examining farmer stories of individual farmers, presented at the end of the chapter, to further illuminate their type of knowledge network, whether or not they adopted cover cropping, and to provide evidence for key findings drawn from coding interviews.

Knowledge Network Types and Cover Cropping

I talked to 20 farmers both over the phone and many of them in person. I documented their stories and then coded the transcripts and notes, searching for knowledge claims and tracing the sources from each farmer to different knowledge systems. I also determined whether the farmer cover cropped or not based on responses to cover cropping adoption. Both knowledge network type and adoption of cover cropping as variables are described in more detail, below, followed by an examination of how they co-vary.

Knowledge Network Types

As a reminder from Chapter 2, a knowledge network is a collection of multiple nodes of knowledge claims and knowledge systems with multiple linkages, which arise via both informal and structured interactions (adapted from Gianatti & Camody, 2007, p. 167). Throughout the interview, farmers made several knowledge claims and hinted at or directly addressed the knowledge sources related to such claims. I then pooled together such claims and knowledge sources (which make up a knowledge system) of each farmer and examined the groupings of knowledge systems. I compared the groupings to the classifications of knowledge network types and assigned each farmer to a particular dominant knowledge network type in which they are immersed. I classify knowledge networks into three theoretical knowledge network types: scientific, experiential, and mixed (adapted from Chapter 2 and listed in Table 5, below). Placing the farmer into a single knowledge network is rather difficult, as all farmers I spoke to are involved in many different knowledge systems that make up each of the knowledge network types in some way. However, all farmers tend to trust a particular source of knowledge and knowledge system over another and also prefer certain avenues to knowledge acquisition, allowing me to group farmers in one of the three types. Based on my analysis, 3 of the farmers who I interviewed are part of a knowledge network dominated by a scientific knowledge network, 11 by a mixed knowledge network, and 6 by experiential knowledge network. Categorization of each farmer is provided later in this chapter. The high percentage of farmers involved in mixed knowledge networks (11 out of 20) in my comparison of cover crop farmers to non-cover crop farmers may be because I happened to talk with farmers who favor a variety of knowledge sources. Another explanation, explained in the next chapter and also proposed in Raymond et al. (2010), is that a majority of farmers do operate within mixed or hybrid knowledge networks.

Knowledge Network Type	Number of Farmers Interviewed	Characteristics
Scientific	3	> relies on verifiable data > external and internal knowledge claims > retailers, university, experience, farmers > professional field visits > attends meetings all over
Mixed	11	> verifiable data/intuition > external and internal knowledge claims > all sources > different field visits > attends meetings all over
Experiential	6	> intuition/verifiable data > mainly internal knowledge claims > farmers, experience > field visits with neighbors > attends local meetings

Table 5. Number of Farmers Interviewed by Knowledge Network Types and Their Characteristics. Network Types are Adapted from the Literature Review and Their Attributes.

Adoption of Cover Cropping

I also categorized whether each farmer adopted cover cropping (yes, no, or undecided) by asking farmers whether or not they use cover crops, on how many acres, and for how many years. Farmers are categorized as undecided if they either: 1) are currently experimenting but have expressed they are not convinced or 2) have experimented and discontinued but expressed that they may try covers again at a later date. I asked all farmers directly their thoughts on cover cropping, which allowed me to glean this information. Of the farmers interviewed, 13 have adopted cover cropping, 5 are undecided, and 2 have not adopted covers as seen in the first two columns of Table 6, below. Table 6 also shows the average percent of a farmer's land that is currently in covers, the years the farmer has been cover cropping, and the average speed at which the farmer adopted covers based on the percentage and years (on a scale of 1 to 3: 3=Fast; 2=Medium, 1=Slow).

Adopted Cover Cropping?	Number of Farmers	Average Percent of Farmland in Cover Cropping	Average Number of Years Cover Cropping	Average Adoption Speed
Yes	13	49%	7.3	2.5
Undecided	5	3%	2.4	1.2
No	2	0%	0.0	1

Table 6. Number of Farmers Who Adopted Cover Cropping, Percent of Land, Number of Years of Cover Cropping, and Adoption Speed

The table indicates that for the farmers who adopted covers, an average of nearly half the land is in the practice. This number is somewhat skewed because three farmers do it on 100 percent of their land, which is not the norm. The chart also shows that cover crop farmers have practiced longer, which is of course necessary for adoption. Furthermore, the adoption speed (between fast and medium, 2.5) may point out that cover cropping farmers want to cover crop at a larger scale and more quickly to show results sooner. In other words, once cover crops show positive results, the farmer is willing to scale up the practice. Not all farmers have the means or are willing to take such risk. The low numbers for percentage of land, years of covers, and slow adoption speed of the undecided farmers illustrate the hesitancy to adopt the practice on a wide scale, if at all, and includes several farmers who tried it out for one year but are not yet convinced. Many farmers, as detailed in the stories below, need verifiable results over several years before they adopt a practice.

Relationship Between Knowledge Network Types and Adoption of Cover Cropping

I next compare the knowledge network types to the cover cropping outcomes. Table 7 suggests that farmers who are part of a mixed knowledge network are associated with cover cropping (9 out of 13 farmers who adopted are in a predominantly mixed knowledge network) and that farmers within a scientific knowledge network are associated with indecision (3 out of 3 undecided farmers are in a predominantly scientific knowledge network). An experiential knowledge network is split, with more farmers leaning to adoption of cover cropping (4 out of the 6). Four farmer outliers from this exist, two in the "Mixed/Undecided" box and two in the "Experiential/No Covers" box. As discussed in the following sections, such outliers may be a result of factors other than knowledge networks.

Adopted Cover Cropping?	**Knowledge Network Types**		
	Scientific	Mixed	Experiential
Yes	0	9	4
Undecided	3	2	0
No	0	0	2

Table 7. Comparing Farmers Interviewed by Dominant Knowledge Network Type to Cover Cropping Outcome

The relationship of knowledge network types to cover cropping outcome is similar and different to what I had expected. Of the farmers in my study, those in a mixed knowledge network are more likely to adopt cover cropping. This could in part be the case because farmers are surrounded by different people and taking in information from a variety of sources, meaning more opportunity for new ideas and innovation and more instances to compare experiences and authenticate results. What I less expected, however, was that farmers involved in a scientific knowledge network would continue to consider cover cropping after failed trials and/or be actively experimenting with cover cropping. It turns out that in my case farmers within scientific knowledge networks engage in experimentation but constantly seek verifiable data both from on-farm trials and trusted outside sources. In other words, they are hesitant to adopt unless the practice is proven successful making them slow to adopt. I also did not expect to find that any farmer in an experiential knowledge network would not adopt cover cropping. I failed to anticipate farmers steeped in what are considered more conventional methods would have learned from family and their own experiences how to adapt to local conditions without using conservation best practices. In other words, farmers within experiential and intuitive knowledge networks, again in my case study, do not inherently subscribe to outside conservation efforts or improved environmental outcomes.

The results indicate that of the farmers in my case study, a strong relationship exists between a mixed knowledge network and cover cropping adoption. However, farmer interviews revealed that other factors beyond one's knowledge network are also very important to cover cropping adoption and the extent and rate at which adoption occurs. Following, I describe additional factors that lead to the spread of cover crop adoption and highlight three major moments that are present in all cover cropping networks I observed. I also further interrogate the findings from the above section in Chapter 6.

Emergence of Cover Cropping

Based on my interviews with farmers, it became apparent that practices like cover cropping develop or fail to develop from more than just one's knowledge network. I first offer additional factors that emerged from my coded interviews that seem to affect whether, when, and how farmers adopt cover cropping—attitude, supporting network, and farm management/conditions. I then connect these factors to three key moments that allow for the emergence of cover cropping.

Factors that Influence Cover Cropping Adoption

Identify with a Conservationist Attitude

All farmers are very aware that what they practice affects soil health on the farm and water quality in the watershed and downstream. None of the farmers I talked to totally dismissed the idea that the way they farm influences the broader ecosystem in some way. Yet farmers do vary in whether they consider themselves conservationists/stewards/early-adopters. Almost all of the mixed knowledge network farmers explicitly indicate their conservationist attitudes (whether or not they cover crop, though most do as note above) and many belong to a conservation group, whereas the scientific knowledge network and non-cover cropping farmers generally do not consider themselves conservationists.

It appears that self-identifying with these labels tends to lead to at least experimentation if not adoption of some kind of conservation practice—no-till being a common on-field practice in the watershed. The worldview also may open farmers up to various types of information outside of only conventional agriculture information. Perhaps such a mix of information inspires a farmer to try something new.

Extensive Conservation-Based Supporting Network

Farmers become aware of new practices from a number of sources. Some come to learn of covers from local projects and some talk with local experts they have worked with for years. Most farmers draw from a mixture of knowledge sources. When farmers look to make a change, they often seek the council of nearby, trusted neighbors, implement dealers, and/or agricultural consultants. From the interviews, it seems that trusted neighbors and dealers are among the most commonly called upon to aid a farmer looking to try cover cropping. Often times, this person is an expert who has knowledge of the practice through their own trials and experiences. The person almost always lives nearby or within the region so is highly aware of the conditions in which the farmer operates. The farmer does not only rely on one person though. They often consult with long-time friends, family members, and watershed groups to continue to learn more throughout the adaptation process.

The mixture of sources that supports conservation and cover cropping seems to contribute to a greater adoption rate, and the inclusion in a conservation-oriented group is a significant factor. Relying on only one person, a handful of people, or on one's own experience is usually not enough to result in adaptation to covers.

Experimentation Based on Farm Management and Conditions

Likewise, when a farmer tries out a conservation practice, like cover crops, it is rarely only a result of an altruistic attitude. Typically, a farmer notices something is not working on a particular piece of ground and would like to try a new approach. The new practice, though, must work within a farmer's existing operation and provide economic benefits while not sacrificing soil health and environmental quality on the farm. Once the farmer is comfortable with the new practice, it must also not be a detriment to other farmers nearby and in the watershed. For instance, in promoting no-till, weeds could become more resistant to spraying necessary chemicals, and waterhemp might take over and spread throughout the area.

When starting out, farmers rarely experiment on all of their acreage. They often look for problem areas or fields nearby that they can keep a close eye on. Farmers often experiment on land that they own or rented land under a good working relationship with the landowner. Most farmers also rely on government assistance and in some cases a farmer might only attempt a practice if they know they can receive compensation for it—and sometimes this is the only way a farmer can afford to experiment.

From knowledge networks to attitude, supporting network, and on-farm management and conditions, I find that these factors help shape three important moments that allow for the emergence of cover cropping. The moments are present in all cover cropping farmers in my case and not only lead to on-farm trials but to further adoption and a broader spread of covers.

Three Major Moments in the Emergence of Cover Cropping

I find that the three major moments—inspiration, collaboration, and experimentation—are all important in order for a farmer to move from occasional field trial to adaptation. Of the farmers above, 2 out of 20 have not adopted and 5 are undecided. Many farmers site the need for continued experimentation and conclusive scientific evidence. Some sight the lack of clear economic advantage. But, continued inspiration through on-farm observation or witnessing a neighbor’s field, working with a local expert or trusted group, and rigorous experimentation have all led to farmers overcoming these shortcomings to adopt innovative agricultural practices.

Adoption, though, is not a static or linear process. As mentioned in Chapter 2, the innovation diffusion model does not allow for the dynamism inherent in management decisions. I talked to a handful of farmers who practiced no-till for a number of years but then went away from it because field conditions changed. As Coughenour (2003) points out, adaptation may be a more accurate term than adoption because it suggests that farmers are often at different stages in the learning, experimenting, and application of a given practice. Adaptation more accurately characterizes the iterative process between the myriad actors (human and non-human), which under the right conditions can allow space for a farmer to integrate the innovative practice. The practice, too, is often uniquely applied, depending on the farmer's economic, social, and environmental arrangement.

In outlining the three major moments, below, I find it useful to think back to my research question: how do farmers, situated in contexts and networks, create and use knowledges to adopt conservation practices? Hence, the people, ground conditions, knowledges, climates, markets, government programs, all influence the information a farmer receives and shapes their knowledge of a practice. The acquired knowledge, in turn, becomes part of the network that impacts a farmer's decision to incorporate cover cropping. The moments are all composed of different actors coming together to create conditions conducive to adaptation.

"I Saw the Light"

The first major moment is the "I saw the light" moment. The farmer must acknowledge that what they are doing is no longer working, either from an economic, social, or environmental perspective, and wants to make a change. As mentioned, this change could be on a larger, operation-wide level, meaning the farmer makes a shift in tillage practice, for example, on all acres. It could also happen at a small scale. The farmer wants to experiment first on 80 acres. The latter is most common because usually farmers do not make widespread changes until they are sure the new practice is going to work on their fields. Inspiration can come from a variety of sources. The three sources that jumped out to me in my research are:

1. Association (e.g., neighbor, current job, conference)
2. Direct experience—intended or by accident
3. Response to a negative outcome (e.g., clogged ditches, loss of money, loss of butterfly population)

Although on a day-to-day basis a farmer often works alone, their job requires them to interact with others to exchange ideas and information, share equipment, or carry out a task. Farmers ask neighbors what they are up to if they see something different in the neighbor's field. One farmer suggested he tried cover crops out because he had told so many others to do it as part of his consulting work. He then was able to learn about the practice through attending meetings and conferences as part of his job. Others met fellow farmers at a conference who inspired them to try out the practice.

Another source of inspiration is from direct experience. One of my favorite moments during the fieldwork was when a farmer pulled over on the side of the road and had us get out and hop onto his pickup. He told us to look out over the corn field. At first, there did not appear to be anything of interest besides the endless amounts of corn, but then he pointed out the slight hump in the corn. Right where he pointed was a strip of corn now noticeably taller than the rest. The farmer indicated that he had dug up a gravel path a few years back and planted corn into it. Each of the previous years he had received a yield boost right on the spot where the road had been. He indicated that it was moments like this that he began to understand the powers of leaving land fallow and planted in something besides cash crops.

Lastly, farmers typically make changes after a few years of experiencing a negative outcome. I was told again and again about the transition to chisel plowing in the 1980s after farmers witnessed roadside ditches filled with black dirt in the winter time. A couple farmers talked about having highly erodible land, which led them to experiment with no-till. Others mentioned trying cover crops as a practice to counteract the high costs of fertilizers and herbicides. When experiencing a problem, farmers are quick to look to change techniques and methods to address the issue. This can sometimes be the impetus for adoption.

Of course, all of these sources of inspiration work together. Farmers are typically responding to problems that often spawn from characteristics in the physical landscape. Interestingly, such problems can be identified and articulated in a top-down manner, from federal and state agencies through policy and program directives. Other times, a farmer will make the change first and seek government help down the line. For example, a farmer may be fed up with nutrient run-off so will attend a meeting to see what they can do about it. The farmer who has a direct experience may ask his neighbor if s/he is also experiencing a certain phenomenon. Of the 17 farmers in the stories, below, only one of the non-cover cropping farmers and one undecided farmer did not impart a moment of inspiration to me. All cover cropping farmers told me of some moment, association or experience that led to change. Even when a farmer is inspired, however, it almost never leads to adoption without consulting another farmer or agricultural specialist in some way or another.

“So-Called Guru”

The second major moment is that the farmer connects with an agricultural expert or “so-called guru.” The guru comes with a mixture of knowledges, can potentially sway the farmer to change, and directs them on how to actually make such change. Farmers may already be working with a guru and ask for advice. A farmer may recognize that he has poorer soils in one section of his farm and knows there has to be a way to improve that soil. The agricultural expert then makes suggestions based on what they know of the farmer’s fields and assists in making the change. In addition to the guru, the farmer is usually a part of a partnership or farm group that puts on meetings, field days, field trials, and provides information on possible conservation incentive programs. The partnership allows the farmer to meet others in the area experimenting with a new practice and connects them to regional experts. Between the guru and the farm group, the following aspects usually exist:

1. Scientific data, using up-to-date technology
2. Deeply familiar with local context, lives/takes place in same region as farmer
3. Established relationship with farmer, trust is formed
4. Partnership is comprised of a mixture of local farmers and experts
5. Focus is on a small area

Many of the farmers I talked with are adamant about having to have proof before they will adopt a practice. The proof is not always necessary to experiment but is important for adoption. If an agricultural expert or partnership is pushing a certain practice, the farmer will most likely be interested in seeing some type of scientific backing. One farmer primarily relies on university trials as his main trusted source. Some of the best experts in the region run their own trials and replicate them over years to show evidence for why to adopt the practice. They collect soil samples to illustrate increased soil organic matter, monitor yield boosts, and keep track of economic returns. The guru may utilize drone technology or other up-to-date software to collect and analyze a farmer's field data. In one example, the farmer listens to what his guru has to say about soil biology.

> "That's one of the things that [the expert] has been preaching for 15 to 20 years is stimulating the soil biology. So, when I go out to the farm, I'm also trying to integrate how I am trying to stimulate the biology of the land as well as manage the inputs that I'm putting on it. And I think that one's going to go 10 years from now. That's a real big deal" (Farmer 2, personal communication, January 20, 2018).

The expert's knowledge of soil biology in this case influences the farmer to "manage the inputs," which includes cover crops.

The farmer is not only taking in information from the outside and making changes. The farmer has formed a relationship with the guru and trust is established. The two work with the data and take into account the farmer's current management practices. The farmer also knows that the expert is from nearby and works extensively in the region so is familiar with the soil and other farm conditions. The farmer also relies on the number of years the expert has been doing or talking about something specific. The same is true for the partnership.

The farmer typically becomes involved in a partnership or farm group if they are looking to try something out but are not quite convinced or just want to learn more. They may find out about the partnership through a friend or from the SWCD office or local Farm Bureau. The most successful partnerships, drawing on the successes of the Indian Creek Project, are comprised of a mixture of farmers and experts. This means that farmers bring different experiences and management styles and that experts have different backgrounds and areas of expertise. When I am attending steering committee meetings, it is apparent that what works for some farmers doesn't for others, but farmers still compare techniques, talk with farmers trying similar things, and ask experts for advice.

The partnership is also most successful if the area of focus is a sub-watershed, Indian Creek being 51,000 acres. The smaller size means that it is likely farmers will already be familiar with one another so more trusting from the start. Soil and water quality data is easier to collect, and it becomes easier to show improvements over time. Agricultural experts wanting to illustrate a best practice to a farmer always start on a small number of acres to get a farmer comfortable and familiar with the practice. Experimenting on lesser acres first with side by side trials is often most convincing to a farmer. Of the seven non-cover cropping farmers or those undecided, two to my knowledge do not work with an expert or are a part of conservation group.

The Back Forty

The final major moment that leads to adaptation is that the farmer experiments on a portion of land, usually less desirable, owned, and near the farmstead. Almost all the cover crop farmers I talked to had 40 to 160 acres that were not good soil, and they were curious what cover crops would do. Even some of the farmers who did not see success the first year tried again the second. Government funding programs certainly helped many farmers continue. Additionally, being able to try different cover crop mixes and test seeding rates, timing, and planting methods was critical to a farmer fully adopting the strategy. For instance, this farmer discusses the role the government and experimentation played on his farm.

> "Only 80 acres has been cover cropped for about 6 years, and we just kept growing and growing and growing. The MRBI project's out, and we're just growing more. Just trying to see what goes on with it. We're just trying to learn, seeing there's gotta be a better way to do this instead of turning everything black and running that much fuel and everything else. Most of the ground we've got cover crops in is our Bryce Swygert dirt. It's a little rougher dirt, so the soil type's not as good. This 160-acres across the road I own myself, and I keep telling myself if we can change Class B dirt into better dirt why can't we change Class A dirt into better dirt or soil. So, I'm just experimenting across the road here to see what I can learn out of it" (Farmer 14, personal communication, March 15, 2018).

This farmer is influenced by a number of factors, but the key is that he has 160 acres across the road to experiment on. There also seems to be a motivation for him to improve the soil. This can be both to improve soil health from a conservation standpoint but also to boost crop yields.

The other point is consistency. Cover crops do not show real impacts to soil health or organic matter until after at least three years if not seven or more. The farmer above has been doing this for six years and wants to continue to experiment and learn. One farmer told me it took him three years until he got the planting method right on a parcel of land he owned. He mentioned, he would not be afforded the trial and error if this was rented land. Ownership, then, plays a critical role in experimentation. So, too, does instinct. As one farmer put it bluntly,

> "I think some of it's going to be more about trial and error, instinct, and just being a steward of the land and having a feel for it rather than trying to put too much science to it and have it real black and white. Because, I don't know, yeah, I kind of apologize to keep pushing you on this, but I'm just trying to do it through instinct. So, let's say you have three years running of covers, you begin to know the cover crops" (Farmer 16, personal communication, June 29, 2018).

This farmer has 40 acres in the back of his farmstead that he tries out different rotations. He said this is critical to him adopting cover crops on other acreage and helps him to convince other farmers to do it, as well.

Summary of Major Moments

Farmers who incur all three major moments in this watershed have adopted cover cropping. Of those farmers who are undecided, the biggest hang up seems to be the ability to experiment and show successful results on a portion of land. The three moments do not have to occur simultaneously but can happen all at once or spread out throughout several years. In one story, below, the farmer was inspired at a conference but waited until he learned more about cover cropping and received money from a government program.

In reflecting on these moments with farmers at the farm dinner mentioned in the previous chapter, farmers suggested that cover crops differ in some ways to other conservation practices. For one, with covers, the farmer is adding an upfront cost when planting. The seeds, although relatively inexpensive, are an added input. So too, covers may require additional machinery that a farmer either has to hire, borrow, or purchase. No-till might also require additional equipment, but one selling point is that it saves a few trips over the field, saving on time and fuel costs. The second drawback to covers is that the benefits to soil health are usually not apparent until three to seven years. If no-till is already holding the soil in the ground and the farmer wants to boost soil organic matter, this could take many years, while the effects of no-till are apparent right away. That being said, a farmer can see soil erosion and weed suppression effects with only covers fairly immediately but may have to wait to witness the big selling point that covers could replace some fertilizer and herbicide costs.

To counteract upfront costs and time, most farmers utilize government programs to pay for their efforts. The programs, though, can be tricky, as the Conservation Stewardship Program, for instance, does not allow a farmer to add acres that they already are experimenting on. Farmers can save money by sharing equipment but must be familiar with a farmer who has what they need. In talking to one farmer, the problem with sharing is that, due to weather constraints, there are days when a farmer needs to get out on the field on short notice. It is highly beneficial, then, to have equipment already on hand.

In terms of the waiting time to see success, the farmer can work with an agricultural expert to determine the benefits they are seeking with covers, and the expert can collect data to track progress. The expert can also recommend different cover crop mixtures that may be better suited to boost soil nutrients and microbiology. Covers are still a long-term commitment, so making land available to farmers, through government or private sponsorship if the farmer does not have land set aside, may also allow for experimentation without losing profitable acres.

The farmer stories are presented, next, to confirm the categorization of knowledge network types and cover cropping outcomes for each farmer. The stories also illustrate the complexities of knowledge production and exchange within actor networks and the process of how a farmer uses knowledge in addition to incurring the three major moments to adopt covers. In Chapter 6, I offer two exemplary cases of farmers and that of a watershed group to assess how knowledge networks play a role within larger cover cropping systems.

Farmer Stories

I offer, here, the brief stories of 17 farmers[2] who I spoke with over the course of my interviews and fieldwork. I give general information about their operation, experience with cover cropping, dominant and preferred knowledge sources, and attitude towards conservation. The stories are organized into the five groups from Table 7 based on the knowledge network type and the cover cropping outcome: Scientific Knowledge Network Type/Undecided; Experiential Knowledge Network Type/Cover Cropping; Experiential Knowledge Network Type/Non-Cover Cropping; Mixed Knowledge Network Type/Cover Cropping; and Mixed Knowledge Network Type/Undecided). Within each story, I indicate in

[2] I exclude 3 farmer stories from the list of 20 because in 2 cases, farmers are related and have too overlapping of stories. The other farmer, I was able to surmise what knowledge network he was a part of, but, due to the nature of the interview, did not get enough of a background story to warrant inclusion in this section.

italics when the farmer experiences one of the three moments and to what degree: inspiration, collaboration, and experimentation.

I hide any details that could give away the person's identification and at times skew numbers and information slightly. The stories are told from a first-person perspective, in order to emulate the farmer's voice but are *not* direct quotations. Although the 17 farmers are a small sample from the hundreds of farmers in the watershed, the stories collectively help weave a narrative of conservation agriculture and adaptation to innovative practices amid the overarching conventional system proliferating in the region. Each story illustrates a single farmer and their family's efforts to make a livelihood out of farming, while doing the best they can to protect the soils they depend on.

Knowledge Network Type: Scientific; Cover Cropping: Undecided

This first group of three farmers have a knowledge network dominated by a scientific approach and remain undecided about whether or not to cover crop. Scientifically verifiable knowledge about cover cropping did not lead to the intended outcome of cover cropping practice for this group. As I show, none of the three farmers fully experienced the three moments that emerged from coding as associated with cover cropping.

Farmer 2. I am just learning how to do cover cropping. I have some land in crop share, so I am also accountable to the landowner and trying to do what is best for their land. I've considered expanding my acreage of cover crops, which is why I attend different meetings in the area. I want to see if there is a benefit beyond soil erosion. It's a hard thing to measure because of the variability of the weather. Field trials are good, but what happens on someone else's land is going to be different than what happens on mine. It's really hard to find good data out there. I work with a guy *[collaboration with expert]* who does a lot of field trials and has the data, but it's still hard to find a good comparison among data.

I utilize all types of resources. I look across the Corn Belt for what other farmers are doing. I'll talk to guys selling equipment because I know the piece they are selling was used for the practice. I attend a number of conferences. In fact, I was told about cover cropping about 10 years ago at a conference in Indiana *[inspiration]*. I was told to experiment on some land with high traffic areas. At the time, though, the government wasn't sponsoring any programs, so when that came about, I jumped on it to get me started *[only moderate experimentation]*. Any good business needs a network of people. Week to week, I know a handful of fellow farmers. We work together on various projects. We'll meet informally to talk about what we're doing and seeing.

Farmer 3. I grew up on a farm but then went to Chicago to work as an engineer for a while. I recently returned to farming. I learned a lot from my dad, but I also look at magazines and attend meetings and field days as part of the watershed group *[collaboration with partnership]*. I think what's missing most is that we do not have adequate data to prove cover cropping is the right way to go. It may work one year but not the next. I am experimenting on my own farm *[experimentation on own farm]* and hoping to replicate some findings to share with other farmers. So far, I have not come across conclusive evidence to show that cover cropping is the right thing to do over a long period. I think the only way that we will see a widespread adoption of something like cover crops is for the government to either mandate or subsidize them, not that I totally agree this should happen.

I also think that farmers are fairly split in their worldviews. On the one hand, you have guys who really invest in learning about soil health and jump on the bandwagon of conservation and such. On the other hand, you have guys who don't pay attention at all and still out yield the others. But it's also been really wet for the last four years, so we're seeing really good yields. In drought years, things like cover crops could show much more of a difference and get more people hooked. *[no identified inspirational moment]*

Farmer 6. We tried cover crops after a dealer encouraged me to do so *[collaboration with expert]*. We lost about 10 bushels compared to the non-cover crop field. A few years back I was one of the first to try it, but it was a disaster because we didn't know what we were doing. I'm not too enthused about cover cropping at this point, but that is not to say I wouldn't try them again. I don't think that mandating them on every acre is wise or practical, but I am not anti-cover crop. I think they are a good thing.

Our deal is that we'll try out different practices at our farm. We look to the research at universities and private companies and will then try something out. We've been no-tilling beans for 12 years now and started out the first 4 years with a side by side comparison on one of the fields. It's important for us to try something on our own before we adopt it on a broader scale *[experimentation, but on highly productive soils]*. I'm also really involved with a drainage group who got me into covers initially *[inspiration]*. I think it's important to protect our water quality and pay attention to what is coming out of our tiles and going downstream.

I'm also adding software to collect more information on what we are doing. I'm working with our dealer to go over the information, compare it to what he is seeing on the ground, and then making decisions from there. I never thought I'd rely so much on technology, but here we are.

Knowledge Network Type: Experiential; Cover Cropping: Yes

The next group of four farmers are a part of an experiential knowledge network and have adopted cover crops. The smaller acreage and affiliation with local groups and connections to neighbors resulted in cover cropping. All of the farmers experienced the three major moments.

Farmer 5. I have a smaller farm, and we do cover crops on just under 100 acres. I also do no-till. I got into this through the Indian Creek Project *[collaboration with partnership]* and talking to some neighbors and friends of mine. I think the Indian Creek Project was successful because of the smaller size and the ability for us farmers to experiment and try different things *[inspiration]*. I take what I can from the different events the university and others put on and then apply it to my field to see what works and what doesn't. My cover crop acreage is on a field that surface drains, so the covers are good at slowing down the water washing off the field *[experimentation on poor soils]*. The CSP program was helpful in getting me to do it, as well.

It's difficult for us smaller farmers to keep up sometimes, especially if a practice involves investing in equipment. A few decades ago we would share equipment more often. Us smaller guys have to do that if we want to take advantage of some of the more technologically advanced machinery.

Farmer 12. My dad always did things a little different. We always had cattle and had land in hay, and I still do. I wouldn't call myself a conservationist, necessarily, but I do believe that God gave us this land, and it's the farmers job to protect it. I've been using covers for a few years now, and they work pretty good within my small operation *[experimentation]*. My wife is really into growing flowers and other plants to attract butterflies because we realized all the monarchs are gone *[inspiration]*. We used to have so many monarchs that came every year and now there are hardly any. My brother is interested in prairie restoration, so we have some prairie grasses in different sections on the farm and along the ditches.

I own all of my land. This is nice because I do not have to worry about leases or what a landlord wants me to do or anything like that. I usually don't invest in new equipment either. This keeps costs down. I rely a lot on neighbors and attend partnership meetings *[collaboration with partnership]*. We'll share equipment and talk about the different things we are trying out. I grew up with the guy across the road, and we both went to a community college nearby and then came back to the farm. I taught an agriculture class at the high school here for many years but am now retired.

Farmer 15. My dad was a vegetable farmer. I grew up helping him out. I moved to the city for a while back in the 70s and then came back to farming. I've always considered myself a conservationist. I got into cover cropping through talking with people at the local soil and water conservation meetings *[collaboration]*. I've tried many different combinations of cover crops *[experimentation]*. Right now, I do mainly cereal rye on just 40 acres but someday we'll probably expand to more acreage. I have a few farmer friends I'm close with and have been involved in partnerships that promote the practice *[collaboration]*. I watch those guys try it out and go to the field trials and tours. I've been doing no-till for 30 years now. I started out small, just experimenting. It's a challenge though to no-till ahead of corn. With corn, there are so many variables. We usually plant corn early, but ground temperatures need to be warmer.

I'm concerned if us farmers don't change our practices, we'll be regulated like the farmers in the Chesapeake Bay area *[inspiration through perceived negative outcome]*. We do our best to protect the soil and keep it from eroding. I know there are a lot of problems down in the Gulf of Mexico, so we do what we can to keep nutrients from washing into the waterways.

Farmer 16. I have been experimenting with cover crops over the last several years. It's really working out for us. We've got some land behind the house here that we try different things on *[experimentation]*. I also keep some livestock. I've been on this farm since the mid-70s and moved here with my family. My son also is a farmer and will take over for me when I retire. He is also into cover crops, and we are happy to share our successes with other farmers.

I started to think about conservation when I took over an old farm that had a couple hundred acres that had not been planted in anything for a while. The first year I planted the field in corn and had my best yield by far. I attributed it to the dormant land that must have had built up soil organic matter and nutrients from the diversity of grasses and other species sitting on it *[inspiration]*. This fascinates me. I also have some CRP ground and am excited to see what my yields will be if I decide to put it back into working ground. I talk to a lot of people and look at some articles. I've hosted a couple field days, as well. I think that the successes of cover cropping take time, and farmers are not always willing or able to wait. I also think that learning to do cover cropping well really comes down to intuition. Science can only tell us so much. *[farmer is considered an expert in cover cropping]*

Knowledge Network Type: Experiential; Cover Cropping: No

The last two farmers within the experiential knowledge network did not adopt cover cropping. The reliance on generational and experiential knowledge led to limited need for outside involvement with conservation groups or a change in their current operation. The farmers were involved in some key moments but not others.

Farmer 7. I experimented with covers *[brief experimentation]* after a recommendation by one of my seed dealers *[collaboration with expert]*. I did not end up having a good stand because the herbicide I had applied in the summer ended up having an effect on the cover crops. I mostly tried covers to see if they would be effective at weed suppression. We have a serious waterhemp problem here. I've also experimented with no-till, but the weather has to be right. I've got a pond in one of the fields and can see first-hand that the aquatic algae are intensifying. This tells me I need to put on less chemicals, which I do. *[inspiration through negative outcome but leads to other practice]*.

I get a lot of my information from just observing and talking with people. I've learned a lot over the years from my own practice but will look to others for advice from time to time. I got into this whole thing because I enjoy the sport of it. It's all about catching the weather, having good landlords, and staying ahead on equipment. I also like to have good, confident people around. Agriculture is all about quantity, not quality. You see guys buying up large plots of land. I wish farming could be more profitable on a smaller amount of acreage.

Farmer 8. I'm a grain farmer and have about 2,000 acres mostly in cash rent. I learned to farm mostly from my dad. We've experimented with no-till but just do not see the advantages of either. We end up using far less chemicals when we chisel plow, so we're actually saving money. Also, with so many chemical resistant weeds out there, it's just as good to work the plow instead of spraying to keep the weeds down. We have not tried cover crops. I just don't see how it is worth the extra time and costs.

I get most of my information from other farmers and retailers nearby. I don't want to get involved in any government programs outside of crop insurance. I think we will eventually be regulated, so I'm a little wary of that. I do pay attention a lot to drainage and soil fertility. You have to. I do the best I can to protect my ground and don't want to be a polluter for those downstream. I also want to mention that we store a lot of our grain. Storing allows us to take advantage of the best prices. Being able to store and dry grain on our own is a huge money maker even though it's a lot of work. *[no identified inspirational moment, collaboration with expert or partnership, or experimentation outside of no-till]*

Knowledge Network Type: Mixed; Cover Cropping: Yes

The largest group of farmers, nine, are involved in a mixed knowledge network. The assortment of knowledge sources and involvement in local partnerships resulted in cover cropping adoption. The nine farmers experienced all three major moments.

Farmer 4. Well, I inherited the farm. When my grandfather passed away, my family asked if I would take it up, and it's something I've always been interested in, so I did. I work for a conservation group *[collaboration with expert group]*. Once I started to work for them and talking to other farmers about cover cropping, I figured I should try it out myself *[inspiration]*. I also experimented with no-till after the drought year of 2012. I'm pretty convinced now that a combination of no-till and covers is the best for soil health. I also had a landowner who was encouraging me to try covers, which isn't very typical *[experimentation]*. I've been impressed by the number of farmers who are thinking about the bigger picture with climate change and the dead zone in the Gulf of Mexico. It's more than you might think.

Now that I work at this off-farm job, I get information from all sides—meetings, conferences, magazines, other farmers, you name it. I work most closely with my fertilizer dealer. My seed guy convinced me to do all non-GMO corn this year. In growing the non-GMO, I talked to a few fellow farmers who are doing it and picked their brains. It's difficult because in learning from others and by experience, I can only go so far but am still subject to the weather. Another thing that becomes a big factor is all the investment. Modifications to certain practices require investing in new equipment, which can be very costly. I have to talk to my banker to make sure that it's a sound decision and whether I can take out that amount in loans.

Farmer 11. I was a part of the Indian Creek Project *[collaboration through partnership]*. It was very successful in getting farmers and myself to think about and experiment with cover crops *[experimentation]*. I think it was really because we had such a tight knit group of farmers who trusted one another. Talking to farmers and having demonstration plots to show them is important, as well. Then, we can offer them cost sharing programs through CSP and EQIP to help pay for cover cropping. I also worked at soil and water. This is what got me into conservation in the first place *[inspiration]*.

I keep cattle and have a couple hundred acres in row crops. This is not typical for the area. I do rotational grazing for the cattle. I've always liked keeping cattle. It's a little more interesting to me than just row crops. Other farmers may think I'm a little crazy because I can't make as much money off having ground in pasture compared to planting cash crops. We leave our cattle fenced off from the creek. That's another conservation practice I adhere to.

Farmer 13. I'm an organic farmer. My dad got into it a while back *[inspiration]*, and when I got into it following him, I just kept on experimenting. I have about 400 acres and try out different mixtures of cover crops *[experimentation]*. I think it's important to experiment, that way I can tell others what I've tried and what I think works or doesn't. I get my information on how to do all this from a bunch of different sources. I keep in touch with people from the university. We have a steady five-crop rotation and have cattle and pigs. I think it's important to diversify the operation, so we are not relying so much on government programs or insurance or anything like that.

I love being amid all this conventional farming. I get to take what I learned and talk to other farmers in the area about what I they can try. A lot of them will listen, too, especially if they can increase production without increasing inputs. I get a lot out of talking with fellow farmers. *[farmer is considered expert in cover cropping]*

Farmer 14. Soil is like the body. What you put in it matters. We work with a company that promotes enhancing the microbiology of the soil. We think that if we can raise the organic matter in the soil, we'll get better yields, and that's what we are seeing. We've been working with this company for over 20 years *[collaboration with expert]*, and the guy told us to try a few things different than what they were saying at the university, and it worked. I saw improvements, and so I stuck with it. I experimented on a rough piece of ground not far from here *[experimentation on poor soils]*. We tried no-till, then experimented with cover crops. No one else in the immediate area is really doing what we're doing, but it's working for us.

I am involved in a couple government programs. That really helps to pay for some of these conservation practices, like cover cropping. I'm not sure I would be so eager to try them out if I didn't have a little help. But I also have family who are interested in farming potentially, so I want to protect the land for them *[inspiration]*. I've got more land now than I ever expected, and the way farming is going, my son may be growing on double the acreage of what we have now.

Farmer 17. I was getting tired of all the compacted black dirt *[inspiration through negative outcome]*. I knew that there had to be a different way to do things. I like to dive in when I try things out and not just dip my toes in, which isn't too common with farmers. After talking to a cover crop seed dealer, I put a 1,000 of my 5,000 acres in covers the first year to see what would happen *[experimentation]*. The first year, the cereal rye was four feet high. I plant only cereal rye because I like what it does for me. I use it mainly for weed suppression and breaking up compaction and call a cover crop guy who I consider a close friend when I have questions *[collaboration with expert]*. I also do no-till on a lot of my acres. I had a landowner convinced that chisel plowing is the way to go, but I showed him the benefits of no-till through small sample plots on his field.

When it comes to the science of all this, we still don't know squat, from soil microbiology to mycorrhizal fungi. I think the trick now is to take small steps. I talk to neighbors nearby who are experimenting with different things. I think restrictions will only limit innovation. Right now, I have so much tied up in equipment, I have a side business that keeps this farm afloat.

Farmer 19. My perspective on farming really changed when I went on a couple mission trips and witnessed environmental issues in other countries *[inspiration]*. I've been on the soil and water conservation board in my county since my dad left it in the late 80s. I care greatly about water and water issues in the area. We were one of the first families to put out water structures to prevent nitrogen from running off the fields during peak flows. We also have some CRP land. We put CRP on poor ground. I plant certain species to attract the monarchs.

I grow non-GMO corn and beans and sell them to Asian markets. I get a premium price on the commodities this way. I also raise my own cereal rye on garbage acreage *[experimentation on poor soils]*. My grandpa always did this *[collaboration]*, as well. I think this would really speed up adoption if farmers could grow their own covers. The whole point of farming is to make it manageable to do the work. If farmers are able to grow covers for cheap and integrate this into their operation, we'd be in a good spot.

Knowledge Network Type: Mixed; Cover Cropping: Undecided

The final group is of two farmers who are part of a mixed knowledge network and have experimented with covers but have not figured out how to best work them into their systems. The farmers rely on partnerships and neighbors for information but did not fully experience the three moments leading to an indecision on adoption.

Farmer 9. I have some ground that's considered highly erodible land. We no-till those areas. The thing with no-tilling is that you still have to spray a bunch. That is why I like to chisel plow. A lot of weeds are now resistant to different chemicals, but no weed is resistant to steel. I've been interested in trying out cover crops *[brief experimentation on poor soils]* and have done so on a few acres and hope to pick it up again soon. The key is that I have to get the economics right. The economics is what drives the whole thing. Of course, we don't want the chemicals running down the stream either. I had a seed dealer help me out the first time I tried covers *[collaboration]*. I think it's important for the first time to go with someone who really knows what they are doing and has tried out the practice before.

Microorganisms play a big part in boosting soil health and covers could help with this. Farming gets pretty complex and even the guys who are supposed to know about all this stuff seem to be in the dark at times but are figuring stuff out more and more. I also know that drainage is really important. I have tiles on all my fields so am cautious about what I put on, so it does not affect too much downstream. *[no identified inspirational moment]*

Farmer 10. I am fifth generation farmer. I really enjoy the challenge of it and taking in so many variables. We've always been on the leading edge of conservation *[inspiration]*. We experimented with cover crops one year *[brief experimentation]*, but we took a pretty good hit on yield. We tried it a few years prior and had decent yields following. We're still trying to figure out the best way to integrate them into our operation. We just purchased a tractor from a neighbor so will be planting more covers this year.

There are a lot of sources of information out there. The first thing I look for usually are the university trials. They are unbiased and do not have financial interests. I also talk with other farmers. I have a handful of neighbors I trust, and we talk to one another. I also attend some of the watershed meetings *[collaboration with partnership]*. I think in farming there are two groups. One group will experiment with different things and not worry about what others think. These are the early adopters. And then there is the group who are constantly looking to others to make sure they are doing things right and are afraid to try something new.

Summary of Farmer Stories

The first set of farmers are classified in a predominantly scientific knowledge network type because of their emphasis on adequate data and reliance on technology. They also seem to rely on data coming from mostly outside sources, even though they experiment on their own farms. Because of the lack of adequate data, the farmers have not "proved" that cover crops are the right way to go, so are undecided.

The next group, experiential knowledge network type, are mostly categorized as such because they either have smaller acreage and draw from local partnerships and neighbors or are generational and rely primarily on their families and own experiences. The former grouping of five farmers all practice covers to some extent. This could be partly because of land ownership but also because of the involvement in the partnership that pushes cover cropping and other best practices. The latter group seem to be less wanting to change because they view that what they do is sufficient for their operation. Even when the one farmer did try covers and they did not work, he did not want to try again because they did not work with his chemical package.

The group of farmers within a predominantly mixed knowledge network type drew from a variety of sources and own experiences. Their involvement in their own conservation jobs and conservation projects were strong indicators of their willingness to adopt. Those who are undecided both mentioned not quite getting the mechanics and economics down but both also no-till and seem eager to try cover cropping again because they are aware of the advantages based on involvements with local partnerships.

Summary of Chapter

The present chapter started with a comparison of knowledge network types and cover cropping outcomes of the 20 farmers I interviewed. From this comparison, the key point to make is that the mixed knowledge network type is associated with cover cropping adaptation. Scientifically-minded farmers are indecisive based on lack of proof but are still willing to try out covers. Farmers in experiential knowledge networks involved in partnerships are more inclined to adopt covers, while those who are not are less inclined. However, because some farmers fell outside the above correlations, I turned to a more grounded approach to looking for patterns and found additional factors and three key moments that are also influential to cover cropping adoption. I then added the farmer stories to draw out even further the operating knowledge systems, cover cropping outcomes, and key moments of each farmer. But, to go a step further, I bring back in the story of the case study area (sub-watershed) as a whole and broader actor network in the next chapter.

Chapter 6 draws on the stories and farmer experiences to explore the usefulness of actor network theory. I also come back to my conceptual model and compare the conceptual model from the literature to one I created from an empirical basis.

Chapter 6 – Network Building and Adaptation

In this chapter, I employ two tools that come out of actor network theory—spatio-temporal mapping/narration and a concept model—as additional ways to validate and explore how the cover cropping network building process unfolds in my study area, extending from the previous two chapters. Chapter 4 presented a history of the physical landscape and institutional actors involved in conservation agriculture in the study area—both of which constitute what I call knowledge systems. The last chapter examined how the makeup of certain knowledge systems comprises a knowledge network type as experienced by individual farmers and then explored the relationship of type of knowledge networks to cover cropping outcomes at the individual farmer level. I also provided themes and individual farmer stories drawn from interviews to illustrate how knowledge networks are not the sole contributor to cover cropping adoption.

Here, I first revisit the major components of actor network theory. Second, I provide a map and adjoining narrative for the study area, the Indian Creek and Vermilion Headwaters sub-watersheds. I also provide a map and narrative for two exemplary farmers from the last chapter—one exemplary cover cropping farmer and one exemplary undecided cover cropping farmer who has experimented with cover cropping but has not adopted. The maps and narratives are meant to better illuminate the process by which a watershed group or farmer comes to adopt cover cropping and highlight the attributes and key moments that allow for cover cropping to emerge or not. Third, I call back to my concept model and reconstruct the model based on what I actually observed in the field and compare it to the model derived from the literature. I conclude this chapter with a summary of my key findings and how actor network theory tools helped strengthen the findings from Chapters 5 and 6.

Mapping the Process of Transformation

As a refresher, cover cropping is part of a farmer's larger cropping system and not only an endpoint. The purpose of focusing on cover crops, then, is less to laud the farmer for their conservation efforts but rather serves more as a signal for broader farmer and sub-watershed level change. To bound my research further, I measure change at the scale of the farmer and at the scale of the case study. The farmer and watershed network extend far beyond the watershed, but this geography and these actors frame the recognition of adaptation to cover cropping.

After identifying instances of cover cropping at the farmer and case study level, I started the mapping process by documenting the actors in my watershed and providing a rich history and context based on Chapters 4 and 5. I then identified alliances or relationships between the various actors involved or not in the practice. Certain relationships together inspire a series of translations (or associations) among actors.

For the next aspect of mapping, I outline these major associations between the various actors, shown in the maps and accompanying narratives, below. The outline is essentially the actor's lived experiences or interactions with the social and natural world. Such tracing brings to the surface the otherwise invisible stuff of knowledge work (Read & Swarts, 2015). Knowledge work, in my case, is not only the production and exchange of knowledge within a knowledge network but is also an attribute among many within the broader socio-technical system of cover cropping on which my research is focused. In other words, knowledges are created out of a plethora of farmer interactions with people and things, who form different interacting knowledge systems within the knowledge network. The characterization of such knowledge production and exchange is one attribute of several that make up an actor network, together setting the stage for cover cropping to emerge or not, as I demonstrate in the concept models.

To understand what I actually mean by 'associations between major actors', I draw on Read and Spinuzzi for further explanation. Associations come about through moments of translation (or a process of transformation, in my case adaptation to cover cropping), thus are key to actor network theory analysis (Read, personal communication, December 14, 2016). Translation happens when key actors align. It is important to note that actors align out of self-interest, circumstantially, and do not have to agree in order to align. Actors work to form alliances through this process of translation, but throughout this process, alliances can also be broken and reformed (Spinuzzi, 2008). Once the network becomes stabilized through these four moments, it acts as a single entity. Actors can thus be both single entities and networks

(Spinuzzi, 2008). If a relationship is weak, it may fall apart and can destabilize the network. Understanding the different moments of translation helped me to identify them in the field and also allowed me to better articulate and describe the associations.

Theoretical Moments of Transformation

According to actor network theory, transformation is characterized by four different but sometimes simultaneous moments: problematization, intervention, enrollment, and mobilization. Problematization is the process whereby actors collectively articulate problematic scenarios. This can occur at many different levels. The farmer has a problem with low soil organic matter. Microbes in the soil have a problem with lack of food. The watershed has a problem with poor water quality. Aquatic-life within the river has a problem with excess nitrogen. For non-human actors, a problem is articulated when something happens to the thing that deters it from performing its function or leads to its extinction.

Intervention occurs when activities are embraced that are necessary to persuade other actors to accept prescribed roles. In the above examples, a farmer experiments with cover crops on a small portion of ground. The microbes attempt to feed on the crop residue. The covers try and soak up excess nitrogen. Oxygen fights back against the nitrogen within the water. Aquatic-life attempt to breathe. If the intervention is successful, it leads to enrollment.

Enrollment suggests that an actor has accepted the intervention and an alliance is established. The farmer sees a steady increase in soil organic matter. The microbes benefit from the crop residue. The cover crops soak up excess nitrogen. Water quality is enhanced within the watershed, creating a suitable habitat for aquatic life in the river.

The final step is mobilization, in which enrolled actors seek to acquire other alliances. The farmer tells other farmers about his successes and shows them the results. The microbes expand and look for other food. Cover crops allow carbon to be stored in the soil. Aquatic-life prospers.

Read and Swarts (2015) employ two heuristics in visualizing knowledge work within the network building process. The first is a spatiotemporal map, defined by the authors as an “assemblage of ethnographically collected documents, objects, photos, words, phrases, and topoi sorted into associations that display their synchronic and diachronic relations across space and time" (p. 23). Such visual map is accompanied by a narrative description to "explain the nature of the relations among actors" (p. 24). Although there can be limitless actors and translations, having specific research questions that adhere to a specific object (for instance, "head farmer and cover crop field" or "farmers and sub-watershed") helps frame the project—in my case, how does cover cropping emerge? I take a deeper look at the relationship of knowledge networks and cover cropping in my analysis of my conceptual models.

Spatio-Temporal Maps

I include before the map a set of actors and following each map, a narrative. Although the maps are more told from a human perspective, within the list and narrative, non-human actors and their relations to other things and to humans are highlighted as best as possible. The set of actors is of course limited but serves as a representation of the kind of actors within each network as it appeared in summer 2018. The network though is not bound to a particular time but can form out of past interactions—indeed history plays a major role in actor network formation. Because actor networks are dynamic, actors may come on board at different times and alliances are broken and reformed (the biggest example being the weather in its many forms). It is important to reiterate, then, that a network is not a thing or space, but a way for me to explore the process of transformation over time within a particular place.

To draw out both how cover cropping emerges as an adaptation strategy and the influence of knowledge networks, I use three examples from my fieldwork. The first example is of cover cropping at the case study level through the perspective of two consecutive watershed projects. The Indian Creek sub-watershed was selected because it is experiencing an increase in cover cropping. The Vermilion Headwaters, the more recent watershed project, is experiencing less of an increase. Because the Indian Creek Project was wrapped up in 2016, I was able to gather cover cropping data and the percent increase over the six-year period, as indicated in Figure 8, below. I do not have the same data for the Vermilion Headwaters project because it is in its infancy and on-going. So, for the map (Figure 9), I combined the two sub-watersheds because the two have so many overlapping actors, and the Vermilion Headwaters is largely considered a continuation of the Indian Creek Project. This allows the reader to see the successes of the first and the initial efforts of the second.

The second and third examples shown in Figures 11 through 16 compare farmers in my watershed, one practicing cover crops (Farmer 14, in the Mixed Knowledge Network Type, from Chapter 5), the other undecided (Farmer 6, in the Scientific Knowledge Network Type, from Chapter 5). The farmers were selected from the two dominant cells that emerged in Chapter 5 when examining the relationship between type of knowledge network and adopting cover cropping. These particular farmers are selected because they have similar acreages, are mainly row-crop grain farmers, are similar in age, and both come from a farming background. They differ widely, however, in their worldviews, knowledge systems, and are also a part of different social networks and agricultural groups. The first farmer is in the Vermilion Headwaters Watershed Partnership and the second is not but is involved in a drainage group. The farmers are actual farmers from my study area and the maps and narratives are their real stories, but they are given the fictional names Scott and Marvin and some details are skewed to mask identity.

I compare the farmers to show that different actors and relationships lead to different cover cropping outcomes. Although the second farmer is undecided and not totally against cover cropping, he does not currently use the practice but has experimented in the past. His story, compared to the two non-cover cropping farmers from last chapter, also better exemplifies the limited spread of cover cropping in this area, even when other conservation practices are adopted.

Indian Creek and Vermilion Headwaters Sub-Watershed Cover Cropping

	Supporting Network	Farmers	Farms	Policy/Environment	
Indian Creek Project (51,243 acres)	**Network**	**Farmer Attitude**	**Farm Conditions**	**Policies/Programs**	Adaptation to Cover Cropping (5% of farmland, 500% increase in 6 years)
	Farmers/Residents	Conservationists	High Soil Fertility	Farm Bill	
	CTIC	Early/Middle-adapters	High Crop Yield	Crop Insurance	
	Livingston County SWCD	Demonstration Plots	Tiled Fields	CSP	
	NRCS	Stewardship	Smaller than Average Size	EQIP	
	IL EPA	**Farm Management**			
	IL Council of BMPs	70% of county in rent		**Climate**	
	Chemical Companies	Crop Insurance	**Implements**	Variable Temperatures	
	Ag Retailers	Crop Rotation	N/A	2012 Drought	
	Various NGOs	Nutrient Management			
	Various Govt. Agencies	No-Till		**Market**	
	Various Ag Associations	Strip-Till		Low Commodity Prices	
	Knowledge Sources	Edge of Field		High Land Costs	
	Farmers	Tiling		One Earth Energy	
	CTIC	Cover Crops		Cargill	
	Livingston County SWCD	Livestock Management		Local Co-Ops	
	IL EPA				
	IL Council of BMPs		**Capital**		
	Chemical Companies		Government Funds		
	Ag Retailers		Farmer's Land for Trials		
	Various NGOs		Staff Time		
	Various Govt. Agencies		Data Collection Equipment		
	Various Ag Associations				
	Field Days				
	Field Trials				

Figure 8. List of Actors for the Cover Cropping Sub-Watershed Group

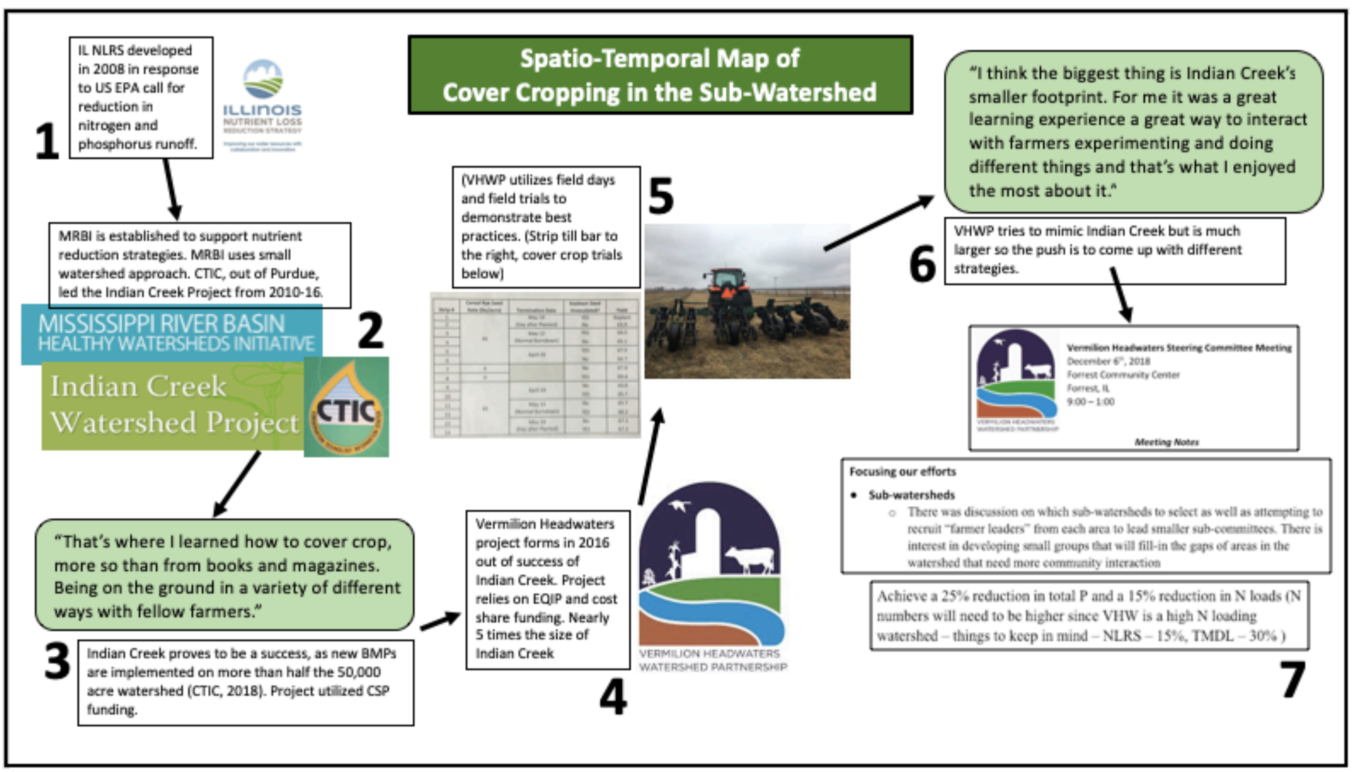

Figure 9. Spatio-Temporal Map of the Cover Cropping Sub-Watershed Group

Sub-Watershed Group Narrative. In 2008, the U.S. EPA developed the Gulf Hypoxia Action Plan. The plan called for 12 states in the Mississippi River Basin to create a strategy to reduce the amount of nitrogen and phosphorus flowing into the rivers and into the Gulf. The U.S. EPA then offered a framework for states to draft plans. The Illinois Nutrient Reduction Loss Strategy was created by a policy working group composed of professionals of different backgrounds at the local, state, and federal level, including the ag industry, non-profit groups, scientists, academics, and water treatment specialists (Illinois DOA, 2019).

The Mississippi River Basin Healthy Watersheds Initiative (MRBI) came out of the EPA's action plan, as well, and is a USDA program that helps guide the work of nutrient reduction strategies. The MRBI uses a small watershed approach to target areas most affecting nutrient runoff. Different stakeholders have come together to lead projects at different watersheds and adapt the reduction strategies based on local watershed needs. A major success story, highlighted on the USDA's MRBI webpage, was the Indian Creek Watershed Project, a priority area located in the larger Vermilion-Illinois River Basin.

The Conservation Technology Information Center (CTIC) out of Purdue led the Indian Creek Watershed Project, which ran from 2010 to 2016. According to a brochure, drafted by CTIC, the project helped farmers in the 51,000-acre watershed to adopt new BMPs on over 50 percent of farmland. It is not known how many of those acres were put into cover crops, but several of the farmers involved in the project expressed learning to cover crop from their time with the project, and cover crops are listed as one of the BMPs.

Partners on the ground included the Livingston County SWCD and the local NRCS office. A farmer who was part of the SWCD office partnered with a NRCS staff member to recruit farmers to join a steering committee. The top goal of the watershed was to reduce nitrates in surface water.

Of the reasons for success of the Indian Creek Watershed Project, a major component that stood out according to CTIC and farmers was the "already close-knit" small community with "long ties through family relationships and church memberships" (CTIC, 2018). The watershed also held tours that drew people from all over the country. The project included a diverse array of participants from local farmers to agribusiness partners.

The project utilized plot demonstrations as the main way to showcase best management practices. Because of the diverse groups, the plots were set up to allow for credible and replicable samples, guided by local conditions with scientific rigor. The key for the project, though, was to focus on demonstrating best practices through exploration of how BMPs worked and could be incorporated into a farmers' operation rather than to prove they were legitimate. The Indian Creek Watershed Project practices were supported mainly via CSP funding.

The Vermilion Headwaters Watershed Partnership formed in 2016 out of the successes of Indian Creek. The VHWP is led by American Farmland Trust and takes place in the larger Vermilion Headwaters watershed (250,000 acres). The project is made up of farmers and ag professionals from state and local groups, including the Livingston County SWCD, Ford County SWCD, and the NRCS office. Farmers in the watershed have access to EQIP, CSP, and a cost-share program.

Similar to Indian Creek, the VHWP utilizes field days and demonstration plots to showcase best practices. Industry experts are often featured at meetings and tours to answer any questions. Local farmers also lead discussions on specific practices, including cover crops, and the management techniques utilized to get best results.

The project has witnessed some successes and draws good crowds to the farm tour events. Cover crops are still a hard sell. The steering committee recognizes that they need to come up with a baseline measurement to show improvements in water quality, something that Indian Creek was able to do successfully but is harder to do in a larger area. The steering committee hopes to target smaller watersheds to focus efforts. The watershed group also wants to involve retailers, as a way to further connect farmers not a part of the project. The goal is to increase conservation practices in the watershed by 40 percent and to reduce nitrogen loads by 15 percent, matching NLRS goals.

One farmer in the watershed tested out cover cropping on a field going into soybeans. He worked with AFT and received money through the Farm Bureau. He frequently updated the steering committee on results and actually found that after one year, cover cropping did not do as well as not cover cropping in terms of yield. But he did suggest that certain variables, such as planting date and burn down date are a factor in production.

Figure 10. Sub-Watershed Group Narrative

Cover Cropping Farmer

Head Farmer	Supporting Network	Farmer	Farm	Policy/Environment	Adaptation to Cover Cropping
(Started on 80-acre field)	**Network**	**Farmer Attitude**	**Farm Conditions**	**Policies/Programs**	(50% of farm, 93% increase in 10 years)
	Spouse	Conservationist	High Soil Fertility	Farm Bill	
	Head Farmer	Early-Adapter	Moderate Organic Matter	Crop Insurance	
	Farmer's Son	Experimentation	Earthworms	EQIP	
	Ag Consultant	Clean	Poor Soil in Spots	MRBI	
	Agronomist	**Farm Management**	Hillier Terrain	VHWP	
	Seed Dealer	85% Cash Rent	Above Average Crop Yield	**Climate**	
	Chemical Rep	Crop Insurance	**Implements**	4 Years of Rain	
	Fellow Farmers	Crop Rotation	Red Clover	Wet Springs	
	FCSWCD Rep	Chemical Program	Cereal Rye	Variable Temperatures	
	Landowner	No-Till	Radish	**Market**	
	Knowledge Sources	Aerial Seeding	Rape Seed	Low Commodity Prices	
	Spouse	Cover Cropping	Mustard Green	High Land Costs	
	Head Farmer		Potash	One Earth Energy	
	Farmer's Son		DAP	Incobrasa	
	Ag Consultant		Nitrogen	Local Co-Ops	
	Agronomist		Corn/Soybean Seed		
	Seed Dealer		**Capital**		
	Chemical Rep		80-Acre Field		
	Fellow Farmers		Farmhouse		
	VHWP Field Datys/Meetings		Barns		
	Planter		Storage		
	Magazines		Hagie Tractor		
			RTK GPS		

Figure 11. List of Actors for the Cover Cropping Farmer

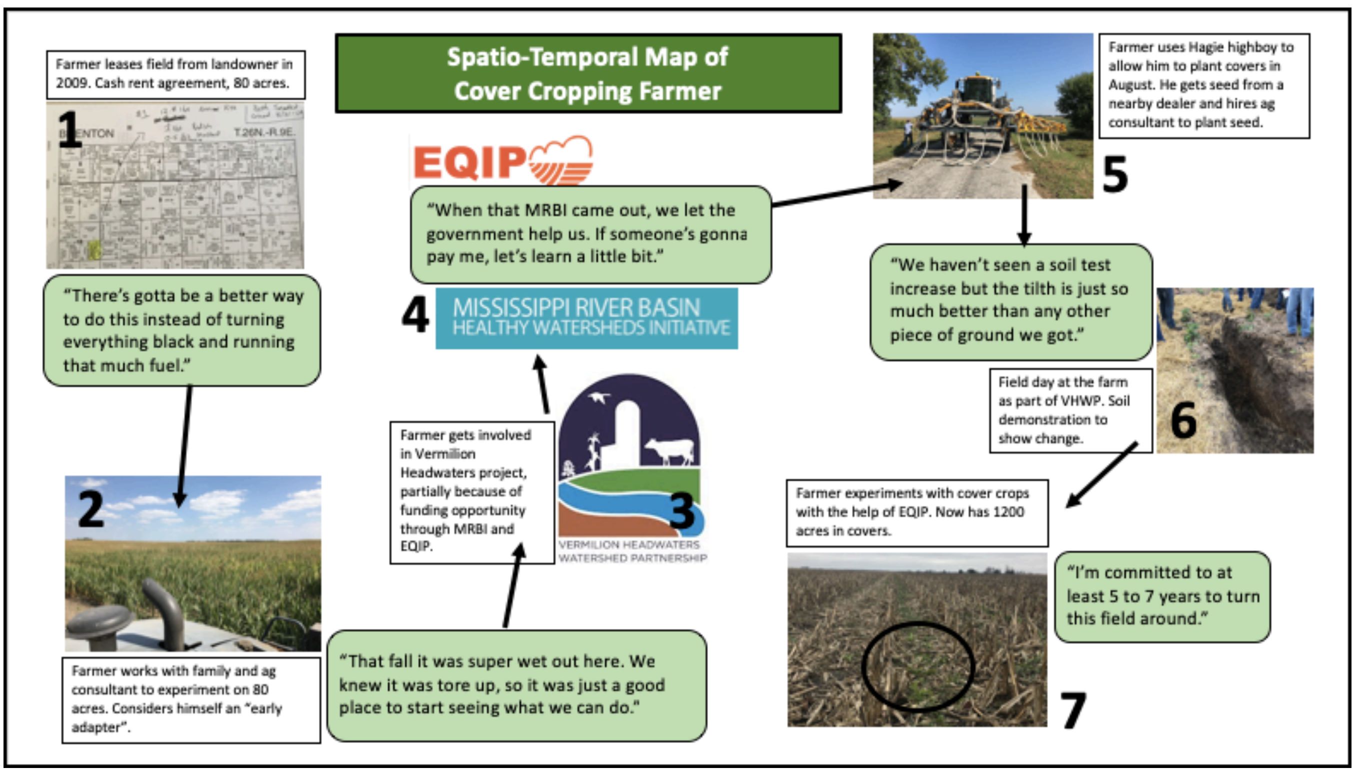

Figure 12. Spatio-Temporal Map of the Cover Cropping Farmer

Cover Cropping Farmer Narrative. Scott leased an 80-acre field from a landowner in 2009 and still leases it today. The field consists of slight rolls and has a few patches of trees and a ditch running through. The landowner had not taken good care of the land at the end; thus, the ground was in rather poor condition both in terms of soil fertility and structure.

Scott considers himself a conservationist and early-adopter so has long had the attitude to experiment with different innovative practices. His dad was also an early-adopter. 20 years prior, Scott met a consultant and started a specific management program. The program was different than what other consultants and the university were suggesting at the time. The program called for less chemicals with an emphasis on feeding soil microbes. The program showed early signs of success, so Scott stuck with it and is still with the program today. Along the way, Scott recognized that tilling everything and leaving the field barren was not the way to go. Scott also wanted to save on fuel costs. The precise time of this illumination is unclear but was part of the inspiration, in addition to the program, to try cover cropping. Having leased a plot of land in not such good condition, Scott found an opportunity to try something new. That fall, the weather was quite wet, and the ground was torn up from prior mismanagement. Scott worked mainly with his spouse and son to experiment on the 80-acres.

Fast forward a couple years, and Scott applied to a conservation program, EQIP, as part of the MRBI program, to help offset some of the costs of experimentation. The extra money allowed Scott to expand his cover crop acreage. In 2016, the Vermilion Headwater Watershed Partnership formed after witnessing success in nearby Indian Creek. Scott was too far from Indian Creek so could not participate in that project. Scott does live within the VHWP's project area. It is unknown how Scott found out about the partnership but is a part of it today. The partnership helps Scott connect with fellow farmers and ask specific questions about cover cropping, other practices, and management techniques. For instance, Scott planted mustard seed one year based on a project expert's advice. In addition to the consultants who help with the management program, Scott also relies on his fertilizer company and looks to farmers who are also trying out cover crops both near and a few hours away. In fact, Scott prefers communicating with farmers a couple hours away because he views them as non-competitive. In years past, some neighbors and companies shunned him for trying out cover crops.

As agricultural technology advanced, Scott was able to buy a Hagie highboy, which allows him to apply fertilizer at different times throughout the summer. The Hagie also allows Scott to plant a cover crop mixture into corn in August giving time for the cover crops to establish and achieve growth before the winter. For the 80-acre field, Scott actually goes through the consultant to plant cover crops. The consultant has their own Hagie that they apply the seed with. Scott works with a local seed company to purchase the cover crop seed mixture. Scott likes to experiment with different mixtures to see what works best for his ground, depending on the variables he is trying to improve.

Over time, Scott did not notice an increase in soil fertility but does see an improved soil structure. Scott gets soil data from his agronomist. Scott also works with the consultant to get high resolution crop data and keeps detailed records and notes to plan for each year. He works with his spouse, son, and farmhand to analyze the data and make the appropriate economic and soil health decisions.

In the past several years, Scott hosted a few field days to demonstrate his successes with cover cropping, as part of the VHWP. The partnership helped to advertise and attract farmers to the field days.

The most influential external dynamics are the market and climate. Since 2009, commodity prices have fluctuated. In 2012, a drought caused poor yields but high returns on crop insurance and high commodity prices. The last four years the region has experienced heavier rain than normal. The heavy rains offer a testament to Scott's work. His fields are able to absorb more rain without having standing water. The heavy rains do make it difficult in the spring and fall to time the planting, but Scott did not seem deterred by this.

Scott is committed to cover cropping and knows that it takes about 5 to 7 years to see results. Having cover cropped for the past 6 years, Scott has adopted covers now on nearly half is acreage. The inspiration to cover crop comes in part from wanting to feed the soil biologicals. Scott learned from a variety of people, most notably the consultant, about biologicals and uses this to justify his actions. He is also proud to have a family to pass off his farm to and this inspires him to protect his ground.

Figure 13. Cover Cropping Farmer Narrative

Undecided Cover Cropping Farmer

Head Farmer (Started on 80-acre field)	Supporting Network	Farmer	Farm	Policy/Environment	Adaptation to Cover Cropping (0% of farm, 0% increase in 5 years)
	Network	**Farmer Attitude**	**Farm Conditions**	**Policies/Programs**	
	Spouse	Conservationist	High Soil Fertility	Farm Bill	
	Head Farmer	Middle-adapter	High Crop Yield	Crop Insurance	
	Farmer's Brother	Experimentation	Tiled Fields		
	Seed Dealer 1				
	Seed Dealer 2	**Farm Management**			
	Chemical Rep	75% Owned/25% Crop Share		**Climate**	
	Fellow Farmers	Crop Insurance	**Implements**	4 Years of Rain	
	University	Crop Rotation	Cereal Rye	Wet Springs	
	IL Assoc of Drainage Districts	Chemical Program	Potash	Variable Temperatures	
	Change	No-Till	DAP	**Market**	
	Knowledge Sources	Tiling	Nitrogen	Low Commodity Prices	
	Head Farmer		Corn/Soybean Seed	High Land Costs	
	Farmer's Brother			One Earth Energy	
	Seed Dealer 1			Cargill	
	Seed Dealer 2				
	Chemical Rep				
	University publications		**Capital**		
	Fellow Farmers		80-Acre Field		
			Farmhouse		
			Barns		
			Storage		
			Field View Software		

Figure 14. List of Actors for the Undecided Cover Cropping Farmer

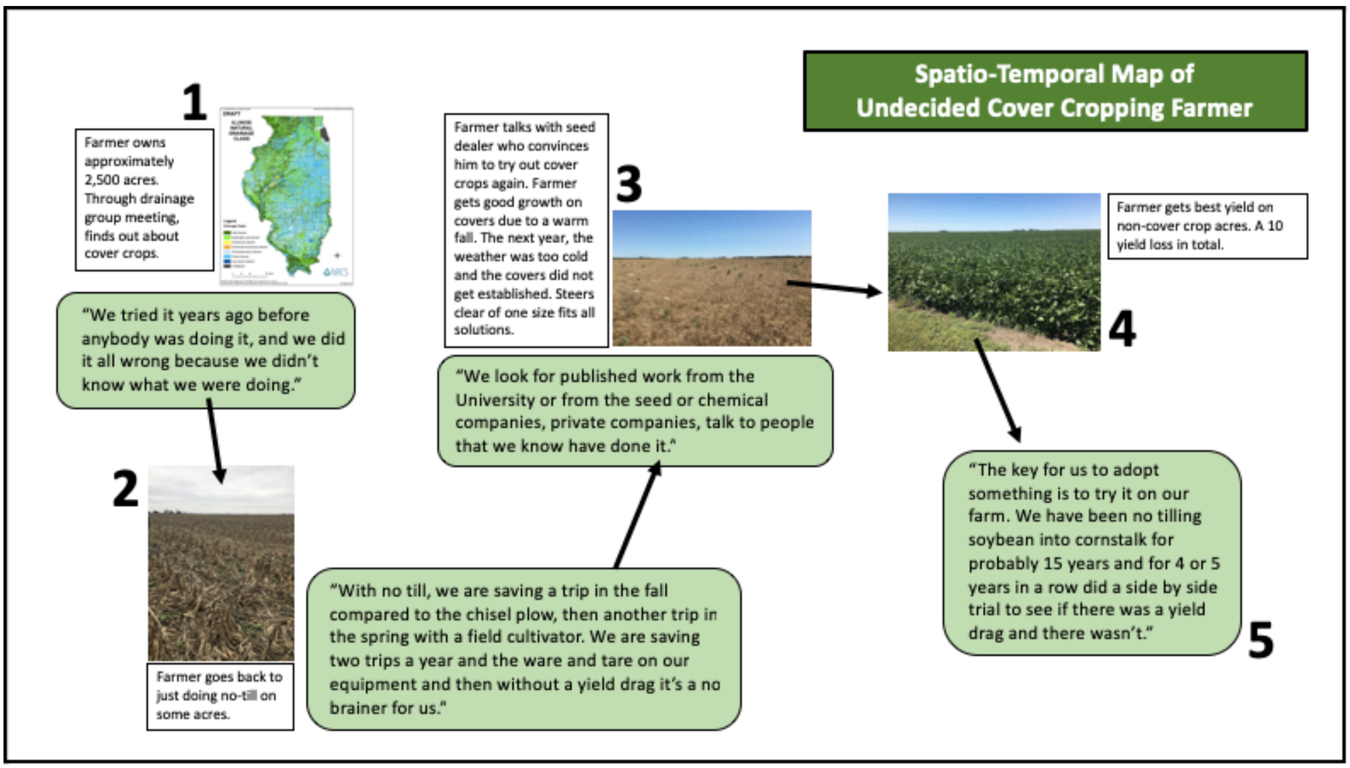

Figure 15. Spatio-Temporal Map of the Undecided Cover Cropping Farmer

Undecided Cover Cropping Farmer Narrative. Marvin has been in the business for 30 years and grew up farming. He owns a majority of his acreage and considers himself pretty typical for the area. He farms with his brother and a full-time farmhand.

Back in 2010, Marvin attended a drainage group meeting of which he is a part. At the meeting, a cover crop specialist spoke about the benefits of covers and this intrigued Marvin. He had some acreage nearby that he wanted to experiment on, so he tried them, mainly out of curiosity. But, as part of the drainage, he also was aware that nutrient runoff was a big issue in the area, especially because most of the field are tiled. The first year was a disaster. The covers did not get established and Marvin did not try again for some time. Marvin holds that covers are difficult because this far up north, the cold weather makes it a challenge to get any growth before the winter hits. Just a hundred miles south, and it would be a whole new ballgame. Some years it will work, some years it won't.

Before covers, Marvin has been doing no-till beans for the past 15 years. The first five years, Marvin experimented with a side by side trial to find out if there would be a yield drag. There was not. Marvin liked that he was saving on fuel costs and equipment ware-and-tear.

A few years ago, Marvin was approached by his seed dealer, who talked him into trying covers again. Marvin respected the seed dealer who also planted cover crops on his own farm. The seed dealer helped Marvin along the way. Marvin did a side by side comparison on a field, planting soybean into cereal rye. Unfortunately for Marvin, the cover crop field had a lesser soybean yield than the non-cover crop field. That year, the field without covers was his best soybean crop he ever had.

Marvin typically looks for published work out of the university or works with a couple of trusted dealers. He believes the certified dealers have a vested interested in his field because they want their product to go well. Marvin also believes that the extra eyes on his field allow him to spot something he may have missed. He does not work with an agronomist.

In regard to changing practices, Marvin does not change very often. The only reason he would is if he found something better than what he was doing. Based on recent high yields, there is no reason for him to change at this point. He likes what he sees. At the same time, he does see the value to cover crops and does not dislike them. If there was a way for him to fit them into his present operation without taking a hit on yield, he would. He is discouraged by national groups who offer a one size fits all scenario to farming. To him, he has been farming the same ground for 30 years so would have a better instinct on what to do than an outside group. Marvin is aware, though, that even though he acts as an individual and wants to be left to his own decision making, he holds that any practice cannot result in the detriment to other farmers.

Similarly, Marvin does not get involved with most government programs, outside of crop insurance. The problem for him is that the programs end up costing you more in the long run and may not actually be as beneficial as what he is already doing.

Marvin has recently adopted GPS technology that he uses to collect detailed data about soil conditions and yield. He consults with his dealers, who also scout the fields for him, to make decisions on crop management.

Ultimately, Marvin considers the possibility of attempting covers again but has to see it work on his farm for a number of years before he will adopt the practice. At this point, the two failed attempts have led to disappointment, even after working with local experts.

Figure 16. Undecided Cover Cropping Farmer Narrative

Sub-Watershed Project Level Analysis

For the sub-watershed project analysis, I focus on the role of conservation policy and agricultural professionals in helping farmers within the watershed adopt cover cropping and other best management practices. I find that both play a key role in cover cropping adaptation in the Vermilion Headwaters watershed, particularly in the smaller Indian Creek watershed. I present, next, two factors, conservation policy and the supporting network and knowledge systems that lead to cover cropping adoption at the sub-watershed level.

Conservation Policy. As detailed in the map and narrative, the impetus for the Indian Creek Watershed Project and subsequent VHWP was entirely born out of federal policy direction from the U.S. EPA. The history of the tension between water quality issues and intensive agriculture is far more than I can cover here, but suffice it to say, evidence to the causes of population of aquatic life in the Gulf of Mexico pointed directly at industrial farmers within the Mississippi River Basin. EQIP had been in place since 1996 with CSP following in 2002 and redrafted in 2008. The direction to adopt nutrient loss strategies refined the attention to particularly polluting target areas. Farmers within these watersheds then had priority access to apply for conservation funding.

The creation of the MRBI allowed for a federal, programmatic structure to oversee state and watershed level initiatives and projects. MRBI, in accordance with the nutrient reduction strategies, identified the heavy polluting watersheds. Funding was also allocated to support federal and regional agricultural groups to oversee the watershed projects.

EQIP and CSP, explained in Chapter 4, require farmers to choose from a menu of conservation practices. Both watershed projects, however, stress that such programs are voluntary and that farmers who want to get involved in the project can benefit through incorporating voluntary conservation practices. The VHWP points out that one of the major benefits to the project are the voluntary aspects, in order to "fend off potential future regulation." Almost all farmers at some point in our conversations mentioned the looming threat of regulation. Each pointed to the Chesapeake Bay area, in which farmers had been heavily regulated for excess nutrients seeping out into the Bay. Ironically, the very conservation programs that inspire some farmers to continue to experiment with covers also pushes some away due to the restrictive nature of the programs. Farmers continually talk about the need for more flexible funding programs. That said, to participate in the project, a farmer does not have to sign up for the programs and can still be on the steering committee or conduct on-farm trials and get compensated in other ways.

Supporting Network/Knowledge Systems. The leading state-backed conservation groups on the ground in the state of Illinois are the county Soil and Water Conservation Districts. Formed in the late 1930s, recently Illinois SWCDs are dwindling in capacity due to state budget concerns with roughly 70 percent of operating funds coming from the state. SWCDs help to protect land and water resources through promotion of conservation best practices. The districts also provide technical and administrative support to the USDA to implement Farm Bill programs, such as EQIP and CSP (AISWCD, 2019). In the Vermilion Headwaters, the Livingston County SWCD and the Ford County SWCD play a vital role in assisting farmers with these programs and helping to support local initiatives like the VHWP.

The NRCS, funded through the USDA, operates out of the same office as the SWCD. The NRCS also offers technical assistance to farmers and landowners and helps to administer financial assistance programs. The Pontiac Service Center in Livingston and Paxton Service Center in Ford house the NRCS and county SWCDs in the Vermilion watershed. The Illinois EPA and Illinois Department of Agriculture are other federally backed agencies that work to draft guide legislation and policy around agricultural conservation. The Illinois EPA was vital in creating the framework for demonstration plots in the Indian Creek Watershed Project (CTIC, 2018).

Non-profit organizations, such as CTIC, AFT, The Wetlands Initiative, and The Nature Conservancy, are also vital to protecting soil and water resources. Such groups often add capacity and support in communication and coordination. With shortages in funding at the federal and state level hindering the NRCS and SWCDs, such support has become crucial for the continued conservation efforts in the state and in local watersheds.

Private entities include crop consultants, agribusiness groups, and local agricultural retailers. As stated previously, farmers are very reliant on consultants and retailers for expert advice and most work closely with one or more of these experts when making management decisions. For instance, The National Corn Growers Association administers the Soil Health Partnership program—a farmer-led program with a goal to "aggregate and measure the beneficial effects of long-term innovative soil management strategies" (SHP, 2019). SHP seeks to gather scientifically-backed data over the course of 10 years and works with farmers across the Corn Belt. SHP plays a supporting role in the Vermilion Headwaters with expertise in cover cropping and other best practices.

The Indian Creek Watershed Project was a result of the collaboration between the above groups and farmers on the ground. The project was successful because of this collaboration. In the Indian Creek brochure published after the completion of the project, CTIC points out other keys to success, as well, including: common goals; community spirit; diverse committee; sharing the load; valuing opinions; demonstration format; taking risks; keeping it interesting; and multiple contacts with farmers (CTIC, 2018).

Observations. Of these key points from the Indian Creek Project, defining clear goals, mixture of experts and connecting with farmers, and demonstration format are most relevant to highlight. Interestingly, these points mirror the three key moments (inspiration, collaboration, and experimentation) detailed in the last chapter. The VHWP, as shown on the right in the spatio-temporal map, is in the process of formulating clear goals and defining attainable bench marks. Without such bench marks, it makes it difficult to show improvements, and farmers and other stakeholders lose interest in the project because they do not see a reason for their efforts. The benchmarks do need to be attainable and catered to the project area, as some farmers lose faith in programs with goals that seem impossible to achieve. Because farming conditions vary across the state and even county, watershed level goals backed by local farmers are more credible. The mixture of stakeholders allowed for a mixture of expertise and knowledge sources. The experts helped to set up demonstration plots, advise on modifications to practices, and relay experiences from other farmers. Local experts also brought knowledge of the watershed and local soil and climate conditions. Because farmers are busy throughout the year, especially during growing season, allowing for multiple avenues to connect worked to communicate key messages, articulate goals, share information, and establish trust. The demonstration format was important in that it allowed farmers to view cover cropping practice variations in multiple scenarios across the watershed.

Lastly, I think it is important to add the length of the Indian Creek Watershed Project, six years, allowed for farmers to see results over time. The continued mention of the time for success in cover cropping makes it so that even a three-year project would not allow enough time to witness much change. Currently, the VHWP is funded through 2019 but is constrained by financing mechanisms at the state and national level. It is too early to assess the VHWP at this point, but the project uses Indian Creek as a model, and many partners and farmers from that project are connected to the VHWP.

Farmer Level Analysis

The above narratives are only 2 farmer stories of the 20 that illustrate how a farmer actually comes to adopt cover cropping, is undecided, or does not. There is obviously much more to the stories and many more actors who/that contributed or made it a challenge to adopt cover crops. The stories, however, are exemplary of the many I heard in my time in the field and are also representative of what I heard from agricultural professionals leading up to the interviews and field visits. Following, I lay out the similarities and differences among each farmer and the key aspects, extended from Chapter 5, that led to the farmers' decisions to experiment with and adopt covers or not.

Attitude/Behavior. As illustrated, farmers' attitudes and behaviors are obviously a key factor in decision making processes. Farmers' conservation attitudes are important determinants of a farmers' behavior or action (Arbuckle's and Roesch-McNally, 2015). Based on themes derived from my interview transcripts, I break down farmer attitudes into three major categories: worldview, social arrangement, and resource management. The categories also draw on Berkes (2012) framework for knowledge and practice.

The first is a farmer's worldview, which "shapes a farmer's perceptions and gives meaning to observations of the environment" (Berkes, 2012, p. 18). The farmers above both have a certain environmental awareness or stewardship approach coming out of both religious backgrounds and time in the field, with Scott labeling himself an early-adopter and conservationist. Scott also recognizes that his family has always been early-adopters. Marvin, on the other hand, does not label himself as such. Although, he is aware of conservation issues and is a part of the drainage district group. A farmer's worldview affects how open s/he is to change. Scott was aware that the black dirt was no longer an option, while Marvin needed years to confirm a change to no-till. Other farmers suggest intuition and inspiration as foundational impetuses for their own adaptation.

The second is a farmer's social arrangement. This level of attitude pertains to a farmer's perception of others and locates the farmer in a larger social and institutional sphere. Scott is less willing to share his experiences with others because he views himself in direct competition with neighbors. He still, though, is part of the watershed group, hosts field tours, and consults with local experts in both farmers and industry specialists. Marvin seeks support from university research but does not engage with researchers directly. He is happy with the couple consultants and his own knowledge of the farm. He is a member of a drainage group that invites organizations to talk on conservation best practices, including covers. Both farmers tend toward individualistic attitudes to some degree. Marvin seems more so, claiming a farmer's right to their own decision making, while Scott takes pride in his difference to other farmers based on his conservation achievements. Trust also plays a role in social arrangements. Both farmers place a lot of trust in the consultants and retailers they work with and listen to their advice.

The third category is resource management, which serves as a technical interpretation of farming practices and how the practice fits within the larger farming and environmental system. Here, efficiency and aesthetics were commonly brought up. Farmers are stretched to plant traditional commodities already, so it is hard to also ask them to add cover crops to the rotation. As one farmer claimed, "It's been documented and reported that there are fewer workable days in a given growing season than there were 25 years ago. So, they see that as a way they need to maximize efficiency, so they're getting bigger faster machinery" (Farmer 13, personal communication, March 18, 2018). Marvin was frustrated with results of the covers and could not see a way to incorporate them into his present operation without set back. Scott had the necessary equipment to efficiently incorporate covers at a time that worked best on his field.

Supporting Network/Knowledge Systems. One major barrier to cover crop adaptation, based on interviews and adoption literature, is lack of knowledge, or more precisely interpretation of knowledge. How to actually grow cover crops is widely known but whether or not they will be successful on any given farmer's field is more challenging. A farmer's field can be significantly different than even another field just down the road. As Marvin experienced, cover cropping on his field did not work, whereas on his consultant's field in the same year and same county, they were more successful. This could be based on experience, farm conditions, or knowledge, and could also mean that covers are not suitable for that particular field. In any case, the farmer, working with consultant or partnerships or not, must understand numerous aspects related to covers in order to be successful, including: soil type, composition, structure, fertility levels, and moisture levels; equipment needs and how to operate; timing; seed choice; planting conditions for covers and following cash crops; termination dates; and chemical program conducive to cover crop growth, among other production factors.

Because such extensive knowledge is required, farmers often lean on retailers, consultants, and agricultural professionals, in addition to attending meetings, conferences, joining watershed or conservation groups, and reading magazines and internet articles. Scott drew mainly on his family, own experiences, and that of his consultant for farm decisions. Scott also relied on local experts and the VHWP to refine cover cropping techniques. His close relationship to his consultant and years of trust seemed to help continue the farmers willingness and ability to stick with covers, in addition to conservation program funding, which I talk about in the next section.

Marvin also has a close relationship with a trusted consultant in his seed dealers but did not stick with covers. Other farmers in the watershed also failed the first year but did stick with the program. From the map and narrative, above, the lack of a more extensive watershed group dedicated to conservation practices could be the reason for failure to continue, as well as the unwillingness to buy into government programs. However, the farmer did adopt no-tilling. One argument for why the farmer does not cover crop is that no-tilling is sufficient for the farmer's need to produce a good yield and reduce nutrient runoff. Several farmers I spoke to echo this sentiment that no-tilling does not always lend itself to cover cropping. Others saw the two practices as the best pairing for a superb conservation strategy. Indeed, the two are major tenets of conservation agriculture (as stated in Chapter 4).

Another aspect of Scott's and Marvin's knowledge pool is experimentation. Both are committed to experimenting. Both look to either sponsored or self-imposed field trials as indicators for success and learn from each year's results. Perhaps Scott's involvement in the watershed group led to more farmers and experts in the conversation who are able to make different recommendations. Notably, of the experts who attended the field days, one of them was Marvin's seed dealer. The crossover in knowledge systems and supporting networks is inevitable in a small county and watershed.

Farm Management/Farm Conditions. A farmer's management decisions and farm conditions are also key aspects. In terms of farm management, the farmer must take into account ownership decisions, capital investments (such as land and equipment), farm size, nutrient management, pest management, tillage, crop rotation, drainage, in addition to economic and other management decisions. A farmer learns and adjusts the techniques and methods that best suit his/her operation. Cover cropping is obviously a part of farm management.

Scott is mostly cash rent and invests in up-to-date equipment and technology (e.g., Hagie highboy). His farm is above average in yield for row-crop farmers in the area but as farmers told me, a farm of his size is not at the big producer, 5-to-10,000-acre level. Scott has an extensive chemical program for fertilizers, herbicides, fungicides, and mineral supplements. He uses no-till and strip-till, practices a steady crop rotation, and is mostly tile drained. He relies on EQIP to support cover cropping, a main reason he has expanded the practice to half his acreage. Interestingly, farmers with so much rented land typically are less likely to experiment, although Scott still mostly experiments on his owned acreage. Cover cropping also fits into his chemical program. Some farmers have trouble establishing cover crops if residue from an herbicide affects cover growth. He has also used mustard greens to kill harmful nematodes.

Marvin on the other hand has mostly owned land. He also invests in up-to-date equipment and technology. His farm is about equal in size to Scott's. Marvin incorporates a typical chemical program and uses a corn and soybean rotation, intermixing wheat as a cash crop periodically. As discussed, he adopted no-till on a portion of his acreage and is tile drained. Marvin does not utilize conservation programs.

Observations. The main difference between both farmers' management decisions seems to be in ownership, conservation program funding, and the use of cover crops in the management strategy. Ownership here though does not lead to more cover cropping and actually has the opposite result. Signing up for conservation programs is significant but is tied to each farmer's worldviews as much as management decisions.

The make-up of the field in terms of soil type, drainage, topography, and compaction are influential in a farmer's decision to cover crop or not and affect the success of the crop. I do not have access to specific data so can only rely on anecdotal evidence. Both farmers are operating under similar climatic conditions with heavy rains and varying spring temperatures in the last four years. Drainage seems to be similar in both farms and both are relatively flat. The key difference seems to be that Scott's field suffered from mismanagement so was in poor condition from the start. The soil had poor fertility and compaction issues, so it had room to improve. In contrast, Marvin's field was the same field in which he produced a record soybean yield that same year. The high yield indicates that the soil was in great condition so had little room to improve. The differences in soil condition is a notable indicator of farmer's willingness to experiment with covers. As mentioned in Chapter 4, farmers in this region are operating on rich soils, so many do not find it necessary to add covers as a nutrient supplement. Some consultants argue instead for the weed suppressant abilities of covers among other benefits.

Summary

The maps and narratives are useful in identifying and validating several findings. Clearly, many paths exist that lead a farmer to adopt cover cropping and a sub-watershed group to inspire widespread adoption. Curiously, although I only look at a couple areas that both seek to adopt cover cropping, among other best management practices, farmers within the sub-watershed, have divergent stories and outcomes.

Overall, however, the Indian Creek Project was considered a success, while the Vermilion Headwaters is still in the midst of working with farmers to bring about broader adaptation. Neither farmer participated in the Indian Creek Project, but Scott is a part of the VHWP.

The maps, narratives, and subsequent analysis pulled out key variables within each network that are favorable to adaptation. At the sub-watershed level, funding for conservation programs and local government agency support is paramount to successful watershed projects. Indeed, many farmers in the Indian Creek sub-watershed got their start in cover cropping as a result of the project. A sub-watershed group is not necessary for cover crop adaptation at the farmer level but appears a major component if cover cropping is to be adopted extensively at a sub-watershed level and make positive impacts to nutrient levels in the waterways. The sub-watershed project should include clear, locally specific goals with attainable benchmarks, a diversity of stakeholders, and many outlets to connect with farmers.

At the farmer level, a farmer's attitude dictates their willingness to experiment and try something new, who they will talk to, and how they manage the farm. Supporting networks and localized knowledge sources can help a farmer interpret local conditions and whether covers are the best practice for a particular field and for the operation as a whole. Enrollment in conservation programs was a key difference of the two farmers, with enrollment leading to widespread adoption on one farm. Another key difference was the field conditions. A field in poor shape that a farmer is able to experiment has more room for the soil to improve and subsequent cash crop yields to increase. Farmers are less willing to experiment on acreage that produces high yields or does not have any drainage or soil erosion problems.

I next use my concept model as yet another way to explore how cover cropping emerges and to further examine the relationship of knowledge networks and practice. Afterwards, I specifically call out my research questions and explore how each theoretical lens (actor network theory and concept model) brought me closer to my findings.

Concept Models

The concept model—the framework I created based on my review of the literature and then adjust based on findings from fieldwork—is an important tool in my assessment of how knowledge networks relate to cover cropping as an adaptation strategy. Referring back to Coughenour (2003), it is important to distinguish between a tightly-coupled system and a loosely-coupled system. The former refers to a particular technique, such as aerial seeding cover crops into standing corn. This formulation of a conservation practice or system is limiting because it views it as a series of techniques to be adopted by the operator. The latter formulation views the system as a set of structures and activities that are weakly connected to each other and thus free to vary independently (Coughenour, 2003). The author goes on to say that both are actually apparent in any socio-technical system and that there is no standard procedure for the system as a whole. No farmer I talked to did cover cropping in the same way, and even when their techniques for planting cover crops were the same, other techniques varied. Therefore, a cover cropping system is highly reliant on not only the specific techniques a farmer chooses to employ, but also on other internal and external variables. What is key to point out is that even after a farmer fully adopts a cover cropping practice, s/he is constantly making adaptive modifications to the system based on the constraints or variables.

First, I present my farmer level concept model from Chapter 2. Secondly, I offer a modified concept model based on the farmer stories in Chapter 5 and the maps and narratives in the present chapter. I then compare the models and relate them to farmer characteristics drawn from the interviews.

Literature Review Model

The Literature Review model (Figure 17, below) shows the relationship between knowledge networks and cover cropping. The idea is that each broad knowledge network type is composed of certain variables that are more or less conducive to cover cropping and affect the rate and amount of cover cropping adaptation. The categories include planning, support network, farmer, and farm, and within each category, I list variables that describe the category. I then interviewed each farmer and based on our discussion locate them in one of the three knowledge network type, using the variables as indicators. So, in theory, a farmer operating with a local knowledge network does not work with outside agencies, relies on experiential knowledge, operates from a stewardship model, and has a diverse farm and will adopt covers at a slow rate.

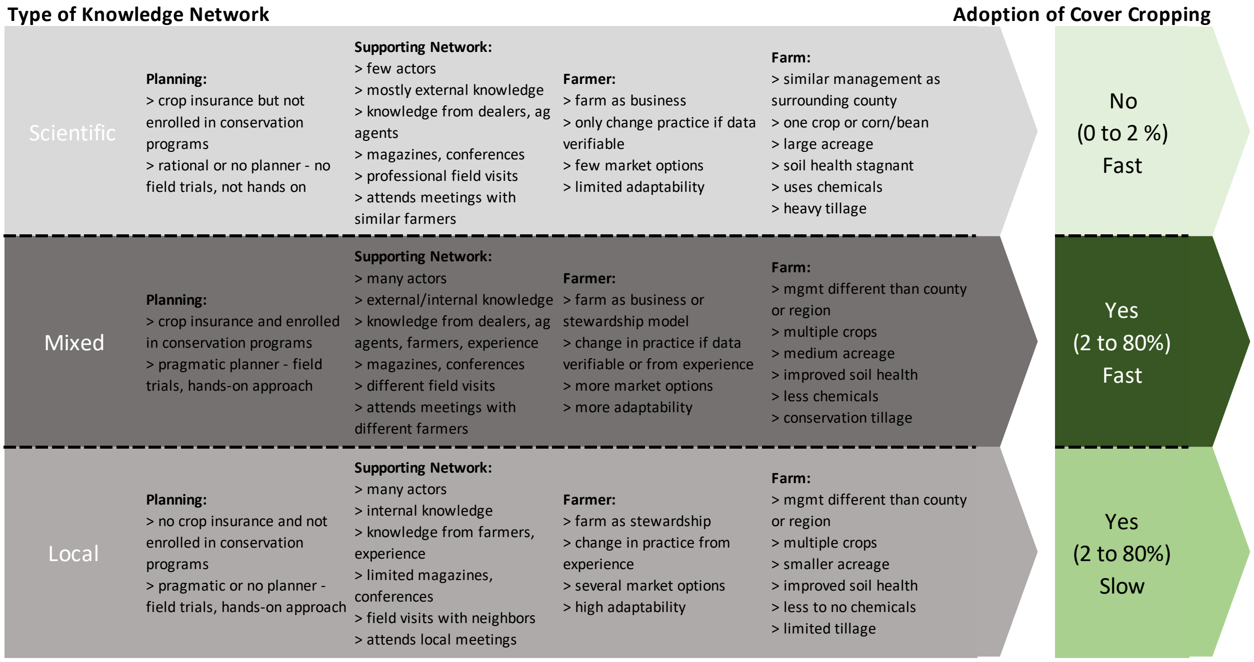

Figure 17. Initial Farmer Level Concept Model based on Literature Review, p. 32., in which Type of Knowledge Network Determines whether Farmer Adopts Cover Cropping.

In practice, the Literature Review model does not hold up. As explained in Chapter 5, all the attributes under each category of a single farmer do not adhere to one knowledge network type. In other words, a farmer may rely on local support but be business oriented and not sign up for government programs. The one such farmer like this in the watershed had not tried covers. The other problem is that no farmer purely is one attribute or another. Notably, all farmers are conservation minded in some ways. One farmer considered himself a steward but not a conservationist. Knowledge systems are also hard to define. In asking farmers where they get their information from, all farmers listed similar sources regardless of whether they practiced covers. Defining external and internal knowledge is also difficult. A farmer might work with a consultant from the watershed, but that consultant may rely on data from another state.

This initial model places the most importance on knowledge networks, indicating that the categories make up the knowledge network type. The outcomes, then, are attributed to the knowledge network type, similar to what I show initially in Chapter 5. Less importance is placed on other defining elements in the network that may attribute to the emergence of cover cropping or not.

Fieldwork Model

The revised concept model based on fieldwork (Figure 18, below) orients the knowledge network type as one of five categories within the overall actor network, a key finding. For this model, I describe four typical, yet varied, actor networks. The networks are only "ideal" types and not real stories. The four networks are used from the farmer types in Chapter 5: Network 1: Undecided/Scientific Knowledge Network; Network 2: Adopted Cover Cropping or Undecided/Mixed Knowledge Network; Network 3: Adopted Cover Cropping/Experiential Knowledge Network; and Network 4: Not Cover Cropping/Experiential Knowledge Network. The categories— "Supporting Network," "Knowledge Network," "Farmer," "Farm," and "Policy/Climate" —are derived from both the literature review and themes pulled from farmer interviews.

In the right-hand column, I draw on 20 farmers from each knowledge network type outlined in Chapter 5 to come up with the averages of the percent of the farm in covers, speed of adaptation, and likelihood of cover cropping. The farmers from each knowledge network type and cover cropping outcome together helped me derive the appropriate attributes of each category for each network. Several farmers fit squarely into one or another network, but some have elements from all three example networks. The knowledge network type, then, does not explain entirely the outcome of cover cropping, as shown in Chapter 5. Instead, a network, bound by the farmer and field, consists of many other actors and interactions, including knowledge networks that can be described using the variables in the empirical model. The model can also be scaled to include analysis at the watershed group and watershed level. Here, I only include the actor network of a farmer and field as it is sufficient in showing what attributes are necessary to cover cropping adaptation.

Network	Actor Network Characteristics					Cover Cropping
Network 1	**Supporting Network:** > family > fellow farmers (all-over) > extension agents > agronomist > Farm Bureau > ag retailers > SWCD/NRCS	**Scientific Knowledge Network:** > relies on verifiable data > external and internal > knowledge from retailers, university, experience, farmers > professional field visits > attends meetings with similar farmers	**Farmer:** > business/stewardship > verifiable data/experience > few market options > limited adaptability > crop yield/soil health > standard chemical program > standard/conservation tillage > mostly rented	**Farm:** > similar management as watershed > corn/bean rotation > large acreage > tile drained > healthy soil	**Policy/Climate:** > crop insurance but not enrolled in CSP or EQIP > field trials with retailer/university > heavy rains; occasional drought > cold, damp springs	Unlikely (5%) Slow
Network 2	**Supporting Network:** > family > fellow farmers (all-over) > extension agents > agronomist > Farm Bureau > watershed group > ag retailers > SWCD/NRCS	**Mixed Knowledge Network:** > verifiable data/intuition > external and internal > knowledge from all sources > different field visits > attends meetings with different farmers	**Farmer:** > stewardship/business > verifiable data = experience > more market options > more adaptability > soil health/crop yield > less chemicals > conservation tillage > mix of owned and rented	**Farm:** > different management as watershed > multiple crops > medium acreage > tile drained > poor soil on some fields	**Policy/Climate:** > crop insurance and enrolled in CSP and EQIP > field trials with mixed groups > Heavy rains; occasional drought > cold, damp springs	Likely (50%) Medium
Network 3	**Supporting Network:** > family > neighbor farmers > watershed group > ag retailers	**Experiential Knowledge Network:** > intuition/verifiable data > mainly internal > knowledge from farmers, experience > field visits with neighbors > attends local meetings	**Farmer:** > stewardship/business > experience/verifiable data > value added market options > high adaptability > soil health/crop yield > less to no chemicals > conservation tillage > mostly owned	**Farm:** > different management as watershed > multiple crops > smaller acreage > not tile drained > poor soil on some fields	**Policy/Climate:** > no crop insurance and not enrolled in CSP or EQIP > field trials on own and with mixed groups > heavy rains; occasional drought > cold, damp springs	Likely (15%) Slow
Network 4	**Supporting Network:** > family > neighbor farmers > ag retailers	**Experiential Knowledge Network:** > intuition/verifiable data > mainly internal > knowledge from farmers, experience > field visits with neighbors > attends local meetings	**Farmer:** > business/stewardship > experience/verifiable data > few market options > limited adaptability > crop yield/soil health > standard chemical program > standard tillage > mostly rented	**Farm:** > similar management as watershed > corn/bean rotation > large acreage > tile drained > healthy soil	**Policy/Climate:** > crop insurance and not enrolled in CSP or EQIP > field trials on own > heavy rains; occasional drought > cold, damp springs	Unlikely (0%) Slow

Figure 18. Farmer Level Concept Model from My Fieldwork in which the Type of Knowledge Network is but One Variable.

On the far left-hand side is the cover cropping a particular actor network. The next column, "Supporting Network" shows the people who the farmer works most closely with. Note, the third network down involves a supporting network with less people and only with nearby farmers, a common attribute of farmers mainly operating out of the "Experiential Knowledge Network" category. The "Knowledge Network" category is the same to that in Chapter 5. Intuition, origin of knowledge source, and location of meetings are key aspects, here.

The "Farmer" category includes worldviews, market options based on crops grown, ability or desire to change, whether they favor crop yield to soil health, chemical use, and land ownership. A major difference in this model is that the variables under each category are intended to be more on a continuum, such as the farmer favors stewardship over a business approach, instead of one or the other.

The "Farm" category describes the management style, crop rotation, acreage, drainage, and soil conditions. Some farmers have healthy soils on every field, while others have poor soils. Some fields are tiled and some aren't. Farmers operating at smaller scales may not be able to afford tiling. Likewise, ownership, often coming from inherited land, may not always be the best soil type. Whereas, with rented land, a farmer is choosing to rent a plot based on good soil health.

Finally, "Policy/Climate" includes crop insurance and conservation program enrollment, field trials, and climate conditions. Note, the climate conditions are typically the same in smaller watersheds. Farm conditions, such as drainage of field, can vary from field to field, meaning similar climate conditions more or less affect certain fields.

The variables or attributes in each category together contribute to the increased likelihood of farmers adopting cover crops. However, a category of the soil quality variable that points to cover cropping for one farmer, such as poor soil, may not lead to cover cropping for another farmer. In short, this model only depicts the combination of certain characteristics that will likely lead to cover cropping. If a farmer meets all of these characteristics, it is likely that they will cover crop or not and at the specified percentage and speed: 3 farmers in the "Undecided/Unlikely/Slow" row; 11 farmers in the "Adopted Cover Cropping or Undecided/Likely/Medium" row; 4 farmers in the "Adopted Cover Cropping/Likely/Slow" row; and 2 farmers in the "Not Cover Cropping/Unlikely/Slow" row.

The concept model from my fieldwork explains the emergence of cover cropping better than only relying on knowledge network type. This is evidenced from the two farmers in Chapter 5 who are part of experiential knowledge networks but do not cover crop and the two who are part of a mixed knowledge network but are undecided. Relying on only the type of knowledge network does not tell the whole story. The model incorporates the elements drawn from coding interviews that together tell a more accurate story of association between farmer, actor network, and farmer behavior.

Usefulness of Tools to Illustrate Network Building

The spatio-temporal maps and narratives, as well as the concept models, draw out actors and relationships within each actor network. Each tool depicts how the combination of actors and interactions lead to adaptation of cover cropping or not. For the maps and narrative, I also provide analysis at the watershed level. Following, I describe how each tool further substantiates my findings from Chapter 5. I then explain how the tools help me answer my research questions.

Major Moments of Cover Cropping Adoption

To reiterate, the farmer stories and themes drawn from the farmer interviews led me to the conclusion that three major moments must be present if a farmer is to adopt cover cropping. The three moments are an inspirational moment, collaboration with an agricultural expert or watershed group, and experimentation on a less desirable field. Below I show what is added by the mapping/narrative and then the concept model in understanding each of these moments.

Inspirational Moment

An inspirational moment most often comes from three sources: by association, direct experience, or in response to a negative outcome.

Spatio-Temporal Map and Narrative. At the farmer level, the map points out the key inspirational moment for Scott that something had to be different. Chronologically, this typically happens at the outset of adaptation. Marvin on the other hand did not have a moment like this yet was still inspired to try it. His inspiration to try covers drew more from his association with the drainage district group. At the watershed level, the inspirational moment is sparked by a negative outcome. Federal and state policy is drafted to develop strategies to combat the ill-effects of nutrient runoff from farmland.

The map and narrative are necessary in that they help point out when in the story the farmer is inspired. The spatio-temporal tool also indicates who is involved at the time of inspiration. The difficulty is that although Scott stated the point at which he was fed-up, in other interviews the inspirational moment is more vague making it harder to pin down an exact moment in time. In other instances, the moment is spread out over time making it difficult to map. The attached narrative can help flesh out a more nuanced inspirational moment.

Concept Model. For the concept model, the inspirational moment may be best captured under the “Knowledge Network” and “Farmer” category. Intuition and a farmer’s desire to draw from experience can lead to inspiration. Furthermore, a farmer’s worldview may also open his/her eyes to change. “Supporting Network” can include people who entice a farmer to change, such as a watershed group or current job. On farm conditions can lead to certain experiences or negative outcomes, inspiring a farmer to try something new.

The concept model is limited, though, to more adequately highlight this finding. The model does not include an attribute for inspiration but does include attributes that serve as proxies. One reason for not listing inspiration is that the model does not show any chronological order. When does the farmer make changes and who is involved at the time of change? This is a major limitation to the concept model.

Collaboration Moment

Collaboration is often between a local guru or a conservation partnership or project. The guru or partnership usually entail the following: scientific data and up-to-date technology; familiarity with the local context; locally located; trust is formed; partnership is comprised of a mixture of local farmers and experts; and focus is on a small area.

Spatio-Temporal Map and Narrative. The map and narrative directly point out the actors in the supporting network who are most influential to cover crop adaptation. For Scott, this is the agricultural consultant. Marvin also works with an agricultural expert. The tool also demonstrates at what point the characters help out and how they work with the farmer through adaptation. A limitation to the map is that it cannot account for every actor, only important moments of the network, in which a farmer interacts with a key actor. The narrative helps to flesh out the depth of the relationship with a guru or conservation group.

At the watershed level, the map and narrative highlight the key human actors involved in making the watershed project work. The watershed group consisted of a mixture of experts, which ultimately led to the success of the Indian Creek Project. The tool also points out the success of the smaller footprint of the watershed. One limitation to the tool is that it is hard to capture the trust between farmer and expert or watershed group. Adding more direct quotations could better represent such trust. The other problem is that the space of the map does not allow for much room to give greater context for each actor. The narrative helps to draw this out.

Concept Model. The concept model directly specifies the influential supporting network. The limitation is that it does not show which of the set of actors are the most influential and how the actor is involved. It also does not elaborate on the strength or weakness of the relationship (or alliance) of the actor to the farmer. The model does show in some capacity how the agricultural expert or conservation group might be involved in that farmers in looking at the “Farmer,” “Farm,” and “Policy/Environment” categories. Also, the “Knowledge Network” category helps flesh out the kinds of information that a farmer and guru/group might be working with.

Experimentation Moment

For a farmer to adopt covers, the third moment is that they experiment on a plot of land, typically smaller in acreage (40 to 160 acres), do so on marginal land (typically owned), and on land near the farmstead.

Spatio-Temporal Map and Narrative. At the farmer level, the map directly highlights the less desirable field that got the farmer started on experimenting with covers. Scott started on an 80-acre piece of land that had been left in poor condition from the previous landowner. At the sub-watershed level, the map also points out the usefulness of demonstration plots to showcase cover cropping successes and the nuances of adopting the practice. The narrative illustrates how the experimental plots allow for the farmer to work with agricultural experts to cater the practice to hyper-local specifications. The narrative also exposes the fact that the non-cover cropping farmer does not have undesirable land, as the field Marvin tested covers on was his best yielding field.

The map and narrative also show the gradual transition from test plot to adaptation and growth of the practice. Sometimes farmers will put covers out only on undesirable land, but if success is shown, they will try it on more and more acres. Graphically, however, the presentation of growth of covers on a farm or in a watershed might be better represented on a literal map or data table.

Concept Model. The concept model is less useful to demonstrate how an experimental plot is helpful for adaptation. Although, some variables like “poor soil on some fields” indicates the need for undesirable plots. Furthermore, “field trials” with different groups shows the importance of experimentation, as do some of the variables under the “Knowledge Network” and “Farmer” categories. Whether or not a farmer enrolls in CSP or EQIP can also indicate their likeliness to try out covers and eventually expand to more acres. The conservation programs are also vital at the sub-watershed level to entice farmer adoption and broader watershed coverage.

The concept model is limited in its ability to show exact acreages or describe the field in more detail. For example, it cannot show the condition of the test plot, the ownership status, or its proximity to the farmstead. Like the map, it also does not show change in the data over time.

Summary of Chapter

Chapter 5 showed that the type of knowledge network experienced by a farmer only went so far in understanding whether a farmer chose to cover crop and that the moments of inspiration, collaboration, and experimentation are critical to a fuller understanding. This chapter addressed the degree to which the spatio-temporal map and concept model were useful research tools in uncovering the important role of the three moments. The spatio-temporal map and narrative seem far better suited to illustrate the three major moments than does the concept model. While the concept model can point out key actors, it is less suitable to show the relationships between the actors and provide any temporal understanding to the adaptation process. The map and narrative can include farmer quotations to add depth and highlight the strength of weakness of each relationship. The tool also can more robustly portrait key moments in time. In fact, this is probably its most powerful use.

The concept model only lists things, people, attitudes, and programs, all which make up actor networks but does not show moments. The concept model more readily shows the key attributes necessary for adaptation but does not show the reader how adaptation comes about. The map and narrative make it more difficult to discern the attributes themselves on first glance without a more thorough reading but do offer a descriptive analysis of transformation.

In sum, the type of knowledge network experienced by the farmer only partially helped understand the degree to which cover cropping occurred—the moments emerging from grounded analysis of farmer interviews added understanding, as found in Chapter 5. This chapter asked how the two methods—mapping/narration at the level of the study area and farmer and applying the concept model—aid in the exploration of the emergence of cover cropping. The methods also included information about the study area and role formal policy has added to our understanding. This chapter found that the two tools can complement one another so are both useful for analysis, and together, they extend the limited story that emerged from looking at knowledge networks of individual farmers alone. Simultaneously, the maps/narration and concept model can also be used to further examine knowledge networks present in a watershed and cropping system. The concept model, though, shifts the influence to the actors and interactions in the broader actor network to better predict outcome, whereas the spatio-temporal map is a snapshot of how a network emerges and is not intended to make predictions, only show key moments and interactions.

The final chapter summarizes my findings from the research and offers recommendations for planners and policy makers involved in conservation agriculture and carrying out adaptive best management strategies. The chapter also gives guidance to methods for future planning and scholarly research in rural agricultural settings and policy environments.

Chapter 7 – Conclusions

This chapter first provides an overview of the research approach, theory, and findings. I then offer recommendation for both planners and policy makers and make recommendations for planning and agricultural researchers. It ends with some brief conclusions.

Summary

I explored how cover cropping systems emerged in the Vermilion Headwaters sub-watershed in north central Illinois by examining the area as a whole and the experiences of 20 farmers. The research utilized pragmatic planning theory by focusing on the interactions between planners and other actors that bring about change. I mainly relied on actor network theory to focus on interactions and network building among human and non-human actors. I provided a rich documentation and history of the landscape and institutional support in relation to conservation agriculture in the region. I created a spatio-temporal map and accompanying narrative at the farmer and sub-watershed level that represented the various actors and their relationships to one another and how an adaptive best management practice is adopted or not. I also drafted a new concept model that better illustrates the complexity of cropping systems and the variables that accompany adaptation.

From a detailed description of place, to the stories, maps, narratives, and concept models at both the farmer and sub-watershed level, I was able to answer the main research question: how do farmers, situated in myriad contexts and networks, create and use knowledges to adopt conservation practices? Following, I summarize the answer to this main question by responding to the sub-questions, elicited in Chapters 4, 5, and 6.

1. What is the extent of cover cropping?

From Chapter 4, at the watershed or county level, cover cropping is very low, only one percent of total cropland. However, in the Indian Creek sub-watershed, not captured by the US Census of Agriculture, cover cropping is occurring on five percent of the farmland. At the individual farmer level, farmers who adopted covers do so on nearly 50 percent of their land, although the range in farmers interviewed was from 4 percent to 100 percent.

Unfortunately, the lack of finer grained cover cropping maps did not allow me to draw more direct conclusions about the relationships between the physical landscape characteristics and cover cropping outcomes. However, even at the county level, one can see the proliferation of cover cropping in central Wisconsin and southern Illinois and draw conclusions that the sandier soils and/or hillier terrain inspires cover cropping as a solution to soil erosion and nutrient runoff. Whereas, in the Vermilion Headwaters, the rich soil and flatter land do not create conditions for the utilization of cover crops, at least to many farmers.

2. To what degree do the region and planners support cover cropping?

Again, in Chapter 4, I discussed the features in the Vermilion Headwaters that make it more conducive to runoff but less conducive to adopting best management practices. The swampy conditions and tile drained fields leads to excess runoff, garnering national attention from agricultural policies and non-profit groups. However, the ownership structure, mainly cash rent, means that farmers are less committed to experimentation of innovating strategies. The Indian Creek Watershed Project and subsequent Vermilion Headwaters Watershed Partnership have been strong allies in the region in pushing for adaptive strategies that mitigate excess runoff.

At the sub-watershed level, watershed advocacy groups are more likely to see success if they focus on a small, 50,000-acre watershed area, have clearly defined goals, work with a mixture of experts, and utilize a variety of demonstration plots throughout the watershed, as witnessed in the Indian Creek Watershed Project and discussed in Chapter 6.

3. To what degree do types of knowledge networks experienced by the farmer explain cover cropping outcomes?

As shown in Chapter 5, farmers who are part of knowledge networks that include both scientific and experiential knowledge are more likely to adopt cover cropping and other adaptive strategies. In my study area, 11 out of the 20 farmers I interviewed were part of a predominantly mixed knowledge network, compared to 3 in a scientific knowledge network and 6 in an experiential knowledge network. Cover cropping adoption occurred with 13 farmers, 9 of which were in the mixed knowledge network category. All three farmers who are part of a scientific knowledge network remained undecided on cover cropping adoption. Purely scientific approaches seem ineffective, even when the approaches draw from localized experiences.

Although, this finding suggests that farmers who are part of mixed knowledge networks are more likely in this study area to result in cover cropping, coding of interview transcripts revealed that other variables also play a vital role in cover cropping adaptation, notably farmer attitude, supporting network, farm management, and on-farm conditions. Along with knowledge networks, these variables/factors create the conditions for three key moments that occur in all cover cropping farmers and only partially in farmers who are undecided or do not cover crop. The moments are inspiration, collaboration, and experimentation. The moments often happen in order but can also happen simultaneously. Furthermore, the three moments more accurately explained the variation in cover cropping adoption than did knowledge network type alone, as all cover cropping farmers experienced all three moments.

4. To what degree does an actor network perspective that goes beyond type of knowledge network explain cover cropping outcomes in terms of a planner's behavior and farmer's behavior?

In Chapter 6, I explored the usefulness to my research of the spatio-temporal map, narrative, and concept model and found that both are useful in my analysis of actor networks. The spatio-temporal map and narrative illustrate the major moments (derived from coding interviews) and the key relationships among actors that help produce cover cropping adaptation over time. The maps and narratives depict the role of planning and policy within the various actor networks. The narrative, especially, tells the story of policy adoption and planner roles and responsibilities at the watershed level. The tools highlight where information is coming from, the preferred knowledge sources, and what knowledges lead to action. Because the tool focuses less on one aspect of a network, the relationship between the type of knowledge network and cover cropping is less defined.

On the other hand, the concept model highlights key actors but does not show the relationships between the actors or provide any temporal understanding to the adaptation process. The concept model sets the context and lists the actors within the network but does less to explain how the knowledges are engaged and transformed into action. The model does better to show the relationship between types of knowledge networks and adaptation, and shows how knowledge networks are only one aspect, albeit an important one, in the process of change. I did find that knowledge network type was better situated within the concept model derived from my fieldwork, which illustrates previous findings on the importance of other factors to cover cropping outcomes.

In summary, all of these methods add to an understanding of the emergence of cover cropping and the influence of knowledge networks. The historical account of the watershed pieced together through in-depth interviews, participant observation, and document review exposed the knowledge systems made up of histories, the physical landscape, and institutional actors. Comparing knowledge network types of individual farmers to cover cropping outcomes showed an association between the two variables, however, four of the farmers were outliers, which led me to further investigate. Coding interviews revealed other factors and three key moments that are necessary for cover cropping adoption. From such coding, I was able to illustrate the emergence of cover cropping in the Vermilion Headwaters and for two exemplary farmers through the spatio-temporal maps and narratives. This tool allowed me to further demonstrate the important relationships among key actors in cover cropping networks. The coding also informed the new concept model categories which brings in the other factors influential to cover cropping outcomes but is less useful in depicting the three key moments of transformation.

Following, I offer recommendations for both agricultural-related planning and policy work and future planning and agricultural research.

Planning and Policy Recommendations

This study finds that farmers relying on a purely scientific knowledge network are less likely to adopt innovative conservation practices, such as cover cropping. The farmer indecision is because a universal, top-down, method of cover cropping application is nearly impossible due to the significant variations in farming styles, soil conditions, and climatic discrepancies, among other internal and external factors. On the other hand, farmers who are part of a purely experiential knowledge network do not always seek to adapt to new practices, mainly because they are limited to knowledge systems nearby that are not always adamant about such change. Thus, for cover cropping to occur, an exchange and integration of knowledges and a more contextualized understanding of existing and new knowledge within cropping systems is necessary to account for on-farm variation. Such articulation and mixture of knowledges may facilitate better interaction between farmers and agricultural-related institutions in regard to innovative practices in conservation agriculture. Such exchange seems most possible when agricultural professionals, researchers, and farmers can together implement field trials over several years and share this information with nearby farmers. The difficulty is that field trials are time consuming and costly to the farmer and can slow down innovation in the short term if results are not as expected.

This study also found that farmers who fully experienced the three key moments—inspiration, collaboration, and experimentation—adopted cover cropping in each case. Agricultural professionals working with farmers may want to assess the extent to which farmers have undergone such moments. For inspiration, an agricultural professional may want to identify the biggest problem on a farm and link cover cropping benefits to solving this problem. Identifying cover cropping seed dealers to work with farmers one-on-one and having more university-led test plots throughout the watershed might also inspire change. Lastly, providing incentives, such as cost-share or stipends, for farmers to experiment with covers on marginal land is important if adaptation is to occur.

The path for agricultural planning and agriculture practice must come together at the small watershed level scale, even in the context of global climate change and trade wars between global powers taking their toll on US Corn Belt farmers. Planners pushing conservation policies must steer clear of "catch-all" policies that do not allow for flexibility at the farmer level. Insight from an array of knowledge systems at the watershed level may help craft place-specific policies and programs. The insight can be captured through on-farm experimentation with farmers and absorbed through conservation-minded, local watershed groups, helping to craft future policy. Adaptation to macro-level circumstances can only happen if planners understand the interactions among place-based knowledge systems and the mixture of producers, agricultural professionals, and localized on-farm conditions. Farmers are well aware of what is happening down-stream but are less willing to change if new practices do not work within their current systems. Working with small watershed groups that include a variety of agricultural experts and local farmers aware of the nuances across the watershed may help to inspire adaptation.

For community development and planning more broadly, the research affirms the literature on co-production of knowledges as a legitimate aim in local development contexts. Planning, urban or agricultural, must aspire to nurture myriad forms of knowledges, favoring the integration of scientifically valid knowledges with on-the-ground experiences. As intensifying weather patterns exacerbate the ill-effects of top-down planning and development schemes of the past half century or so, adaptation strategies that adhere more to local contexts will be better suited to handle the rapid changing environment.

For community development, as well, planners may find that an actor network theory approach improves planning's ability more so than other approaches to assess myriad knowledges related to implementing innovative practices. Mapping projects like the spatio-temporal map in this research, carried out with local populations, can help elicit pervasive knowledge systems and key actors and relationships that inhibit or inspire change. "Deep mapping," for one, is a burgeoning participatory planning method coming out of the humanities and anthropology (Roberts, 2016), and is useful in visualizing and critiquing contested spaces.

Findings might also be applied to issues of renewable energy development. Planners in my research area take the form of the non-profit agricultural organizations at national and regional levels, university faculty, the Natural Resources Conservation Service and Soil and Water Conservation District (SWCD) representatives, and the planning commissions at the county and city levels. One arena that the SWCD and the planning commissions have come to play a more upfront role in my study area is related to windfarms and solar farms. Farmers in my study region are mostly antagonistic toward windfarm companies. As a push for clean energy continues, even amid the downplay by the current federal administration, the development of alternative energy is likely to expand across Illinois farmland. Planners will have to grapple with policy that does not cut out productive land at the expense of farmers' livelihoods and must also seek out companies willing to work with farmers to integrate clean energy solutions within a farmer's operation. Clean energy development, then, is one policy area that could benefit from a more in-depth analysis of various actors and their relationships.

Future Research Recommendations

Future planning and agricultural research will find actor network theory and similar object-oriented ontologies useful for research related to environmental management, conservation agriculture adaptation, knowledge production, and food systems studies. Actor network theory diverges from the usual innovation diffusion model, typical in agricultural research (Schneider, et al., 2010). The theory beckons the researcher to look at not only human relationships but also non-human interactions. Actor network theory makes visible "overlapping systems of knowledge" that form the "networks of relationships among practitioners, scientists, agency representatives, and non-human entities" (Coughenour, 2003, p. 281). With this perspective in mind, the researcher can broaden their approach and experiences in the field. The fieldwork becomes less about why a farmer adopted a practice, looking for the sole entity that led to change. Instead, every person and thing are in play as a possible collaborator in the co-production of knowledges and network building.

My study also has implications for future research on knowledge work, particularly on the categorization of knowledge networks and the role of integrated of mixed knowledges. The concept model offers detailed description on how such knowledge networks can be conceived. Chapters 2, 3, and 5 also provided in-depth measurement techniques for how to identify knowledges and categorize knowledge networks.

Future research should talk to producers who do not practice any form of conservation. I was unable to this in my study, and it made it more difficult to compare knowledge network types and adaptation strategies among cover cropping and non-cover cropping farmers because the two groups were less distinct. In talking with one Ford County farmer, he mentioned row-crop farmers in this region are more typically placed in three primary categories: no-till farmers, organic farmers, and conventional farmers. This farmer also mentioned that most of the time, farmers will only say they are a no-till farmer if they do so on the whole farm. The same is true for cover crops. No farmer will lead with "I'm a cover crop farmer" but do say that they have tried cover crops or that they use cover crops. Also, only the organic farmer I talked to uses cover crops on all his acreage. Another common differentiation is that conventional, row-crop farmers sometimes distinguish themselves as being conservation-minded. This means they have likely adopted conservation practices. Likewise, the farmer is sometimes referred to as an early adopter. An early adopter is someone who typically is at the forefront of adopting a new practice. Almost all of the cover crop farmers I interviewed consider themselves early adopters. A couple suggested that they are middle adopters, meaning they wait until the practice has shown some success in the area or they have more information before trying it out themselves.

Future research may do better comparing innovating conservation-minded producers as opposed to cover cropping farmers to those who do not label themselves as such and select a wider range of practices as adaption strategies. For example, a researcher might compare the actor networks and existing knowledges of a conservation-minded no-till farmer to a conventional farmer operating from less of a stewardship model.

Future research may borrow from the present research to expand on the three major moments, this time examining the strengths of alliances that bring about each moment and the influence on outcomes. My research was less effective in showcasing the difference between strong and weak ties across alliances among the different actors. The farmer stories and spatio-temporal maps and narratives illustrated key moments in network building and cover cropping adaptation, but where farmers did not adopt, I was only vaguely able to point out a weak relationship that may have led to a non-cover cropping outcome. Future research may borrow from the present research to expand on the three major moments, this time examining the strengths of alliances that bring about each moment and the influences on outcomes.

Finally, a comparative study of other Corn Belt watersheds might supplement this present work. I demonstrated in this research how a particular place and the material world within it informs knowledge production and network building. The research is generalizable across north central Illinois in that farmers are operating amid similar climatic and market variations. However, farm management, on-farm conditions, and institutional support vary from farmer to farmer making the research only generalizable to the watershed. Nonetheless, the research could rather easily be replicated, though, in different landscapes outside or within the Corn Belt. The variation in landscapes and the degree to which problems are articulated based on the physical landscape may alter how knowledge comes about, the type of knowledge networks that exist, and other variables that affect conservation practice adaptation.

A comparative study across state lines could also highlight power relationships and imbalances. Because I focused on one watershed within a couple counties and one state, I was not able to make any comparative statements about the influence of power dynamics on conservation adaptation.

Conclusion

In closing, planners can no longer operate out of a rational planning model. This model has been nowhere more pervasive than in agriculture, which is dominated by large-scale, row-crop farming and has been well-critiqued by James Scott's (1998) *Seeing Like a State*, written 20 years ago. Yet, industrial agricultural systems in the U.S. continue to ramp up production, as technology, created and marketed by top-down agribusiness giants, has allowed for record high yields in corn and soybean, experienced by many farmers here in the Vermilion Headwaters. Unfortunately, even conservation agriculture as promoted by the state has, for the most part, not rejected this model. Perhaps consequentially, we have seen that cover cropping, as a conservation strategy, still lacks widespread adoption.

The problem does not appear to be lack of technology, people on the ground, or even lack of knowledge, but a lack of integrating knowledges from techno-scientific endeavors, with intuitive, experiential approaches derived from on-farm experimentation. While the government has indicated a problem at the national scale of excess runoff in the Gulf of Mexico, farmers perceive different problems on the ground and feel more compelled to adapt to site-specific problems. Wary of widespread regulation that does not account for local conditions, some farmers are inspired to get ahead of the game and begin to make changes. Present efforts at the sub-watershed level most certainly need to continue, but attention to site-specific conditions, flexible policy, and integrating more nuanced knowledges, related to issues around soil microbiology for instance, will allow for widespread adaptation and do better to protect vital farming landscapes and water bodies downstream.

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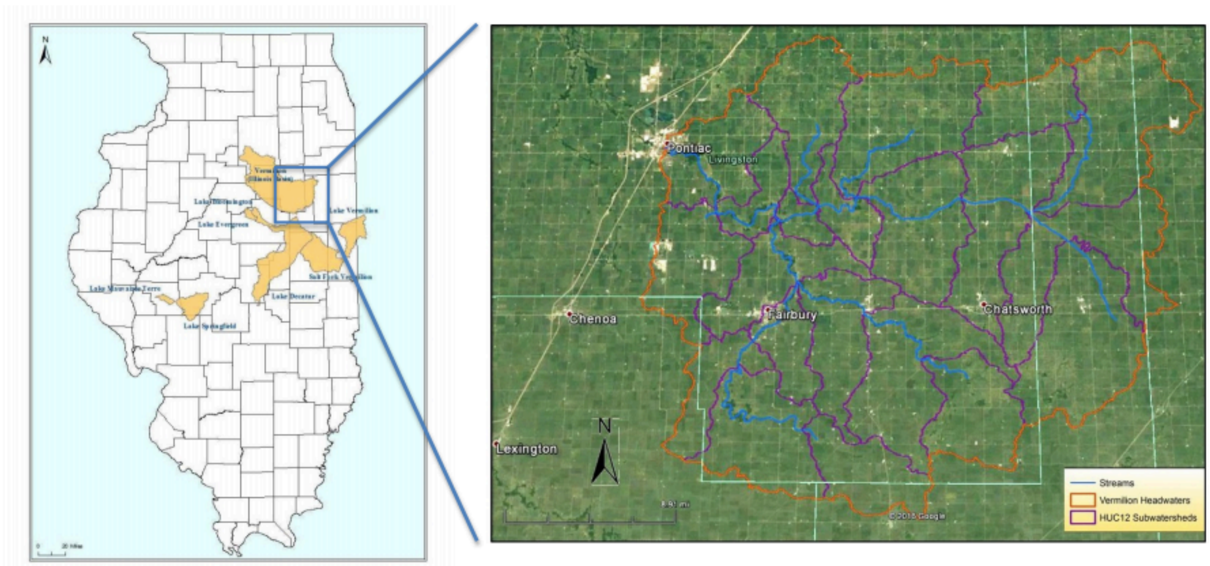
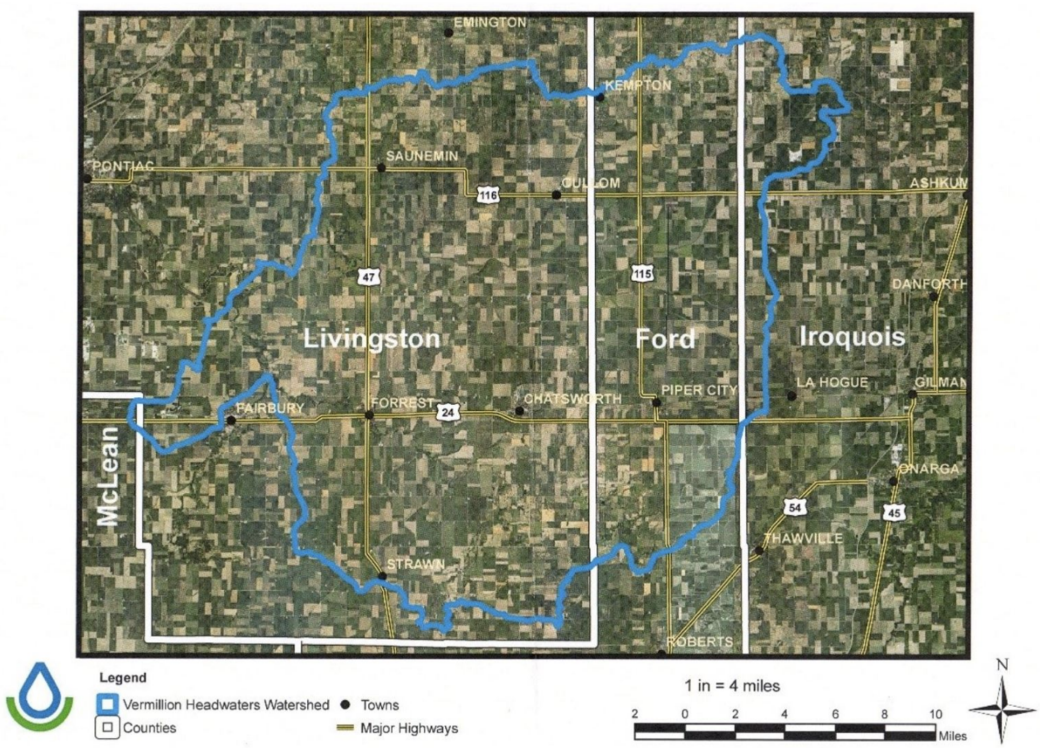
Appendix A – Study Region Map

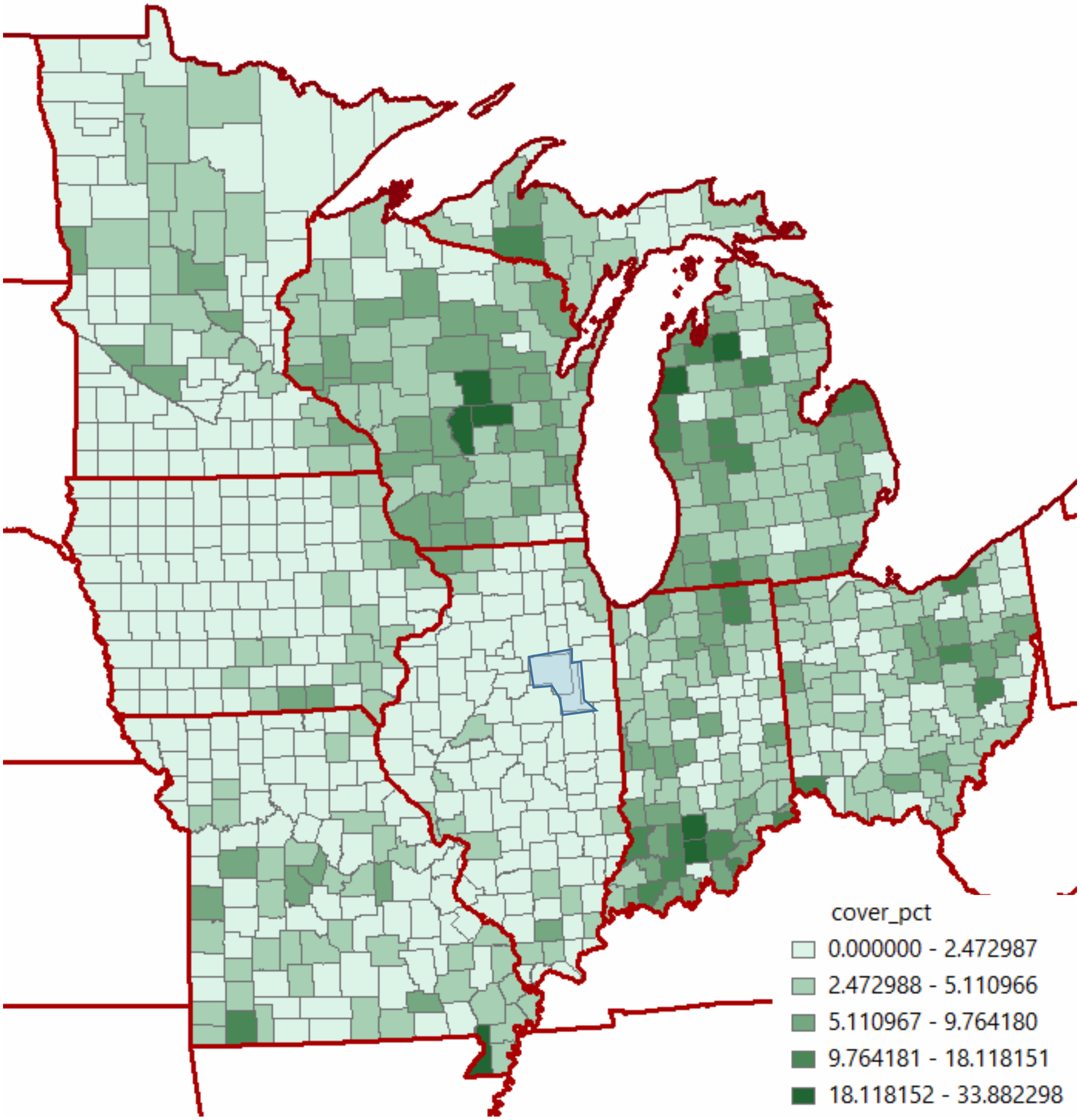


Map of the Vermilion Headwaters sub-watershed in context to larger Vermilion-Illinois River Basin (source unknown)



Map of Vermilion Headwaters sub-watershed and counties (American Farmland Trust, 2018)

Appendix B – Cover Crop Percentage in Upper Midwest



Source: 2012 US Census of Agriculture. Percentage of Cover Crops by County. Livingston and Ford County highlighted in blue. Map generated by Nina Savar at University of Illinois at Chicago (June, 2017).

Appendix C – Study Region Demographics and Farm Data

Demographic data for the study region counties with particular focus on the percentage of farmland compared to the larger Lower Illinois watershed.

Item	Livingston	Ford	Lower Illinois	State
Area (acres)	669,440	311,040	NA	37,064,960
Farmland (acres)	656,275	308,181	9,381,518	26,937,721
Percent farmland	98.0%	99.1%	NA	72.7%
Average farm size	486	564	NA	359
Total cropland acres	632,131	298,030	8,313,354	23,752,778
Harvested cropland acres	614,333	290,265	7,936,943	22,373,010
Population (2017)	36,518	515,269	NA	12,741,080
Population density per acre	37/sq. mi.	29/sq. mi.	NA	232/sq. mi.

Corn and soybean data for the study region counties and larger Lower Illinois watershed with particular focus on the percentage of farmland in corn and soybean.

Item	Livingston	Ford	Lower Illinois	State
Corn for grain total acres	323,873	159,490	4,644,110	12,263,259
Soybean for beans total acres	277,323	125,449	3,079,555	8,933,457
Percent of total cropland in corn and soybean	95.1%	95.6%	92.9%	89.2%

Source: 2012 US Census of Agriculture and 2010 US Census

Appendix D – Geologic Column of Vermilion Headwaters

Vermilion River Watershed Geologic Column, Stella Brown, 2018. Photograph by Stella Brown.

Appendix E – Interview Protocol

To Farmers:
What is the main type of farming you do here?
How many acres of land do you farm?
Do you use cover crops, and if so, what crop and on how much land?
How long have you cover cropped?
Where did you learn to practice this type of farming?
Where did you seek out information? Who did you talk to?
Who do you work most closely with? Who else do you work with?
How often and why do you change farming practices?
Where do you learn about new innovations in farming?
What are your thoughts on XX farm policy?
Do you typically follow federal and state policy news or do you pay more attention to county and municipal policy news?
Do you work with any local planning organizations, county soil and water departments, or non-profits?
In what capacity do you work with each?
What is the most used farming equipment?
How often and to what extent do you use herbicides, fertilizers, and pesticides?

To Planners and Ancillary Professionals:
What is your take of cover crop adoption in the region? Is it happening at a fast rate or do you think it is slow to take off? Why do you think so?
What is your best estimate as to the percentage of the cropland farming in cover crops? Do you think it is more or less than the state wide or national average?
What particular communities practice cover crops more so than others?
What organizations work with farmers to implement cover crops? Does your organization do so?
What has been the reception of farmers in working with them to implement cover cropping?
Do you work directly with farmers, and if so, do you stay active throughout the entire planning process, including monitoring?
How do you spread information regarding conservation best practices?
Is the information derived from university research or is it farmer inspired or both?
In your opinion, what type of knowledge network do you think is most prevalent among farmers in the region? Do you think most of the information is scientific in nature, as far as coming from universities outside the region? Or is it more local, whereas farmers derive information from experience, other farmers, and local organizations? Or is it a bit of both?
How would you conceive of this planning entity being a part of such knowledge network?
Do you work with individual farmers or with larger groups of farmers?
How often do you host meetings on different conservation agricultural topics? What is the attendance/participation like at these meetings?
Are there many meetings that are particularly related to cover crops? If not, why the lack?
What other forms of meetings outside the formal planning meeting that are more effective?

For Meetings:
Who sponsors the meeting and who takes the lead?
What information is passed along and where does it derive?
What do planners look like, how do they dress, and how do they talk and interact with farmers?
Was the meeting supposed to come up with new ideas or pass along existing ideas and does it stick to the planned agenda?

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EDUCATION

PhD in Urban Planning and Policy, August 2014 to May 2019
University of Illinois at Chicago, Chicago, IL
Primary Advisor: Curtis Winkle
Areas of Interest: Political Ecology, Food Systems, Regional Planning, Community Development

Master of Regional and Community Planning, May 2011
Kansas State University, Manhattan, KS
Thesis: Impacts of Professional Sports Stadium Development Projects on Urban Areas

TEACHING AND RESEARCH EXPERIENCE

Adjunct Professor
Ecology of Contested Spaces, Liberal Arts Department
School of the Art Institute Chicago, Chicago, IL, January 2018 to Present

Introduction to Urban Planning, Department of Urban Planning and Policy
University of Illinois at Chicago, Chicago, IL, August 2017 to December 2017

Urban Problems, Department of Sociology and Anthropology
North Central College, Naperville, IL, December 2016 to June 2017 and March 2019 to June 2019

Teaching Assistant
Social Justice, Planning, and Cities, Department of Urban Planning and Policy
University of Illinois at Chicago, Professor Brenda Parker, January 2019 to May 2019

Introduction to Urban Studies, Department of Urban Planning and Policy
University of Illinois at Chicago, Professor Teresa Córdova, August 2014 to May 2017

Master Class with Bruno Latour
Participant, Facing Gaia: An Enquiry on the New Climatic Regime
University of Illinois at Chicago, Chicago, IL, November 2017

Landowner's Field Guide to Leasing for Sustainable Farming
Research Assistant, Food, Farms, and Environment Program, Liberty Prairie Foundation
Grayslake, IL, August 2015 to December 2016

Chicago Area Regional Food System Study
Research Assistant, Planning and Policy Division, Openlands
Chicago, IL, May 2015 to December 2015

PAPERS AND PRESENTATIONS

Peer Reviewed Papers
Corwin, C. (2016). Smith, Leopold, and sustainable agriculture: Imagining today's ethical human. *The International Journal of Interdisciplinary Environmental Studies*, *11(3),* 11-23.

Research Reports
Aaberg, N., Beyer-Clow, L., Brawley, E., Corwin, C., Leibov, B., Gordon, K., …Poole, C. (2016). *Breaking Ground: A Guide to Growing Land Access for Local Food Farming in Northeast Illinois.* Chicago: Food:Land:Opportunity.

Presentations
Use of deep mapping for co-production of knowledges in community development: Lessons from cover cropping in Illinois

American Association of Geographers Annual Meeting, Washington, D.C., April 2019

Deep Mapping and Co-Production of Knowledges in Planning: Lessons from Cover Cropping in North Central Illinois
Associate of Collegiate Schools of Planning Annual Conference, Buffalo, NY, October 2018

Deep Mapping as Methodology: Cover Crop Farming in North Central Illinois
Dimensions of Political Ecology, Lexington, KY, February 2018
Actor Network Theory as Methodology: A Case of Cover Crop Farming in Northern Illinois
Political Ecology as Practice: A Regional Approach to the Anthropocene Conference, Chicago, IL, November 2017

Ecological Knowledge & Aesthetic Appreciation of Nature
Dimensions of Political Ecology, Lexington, KY, February 2017

Local Ecological Knowledge and Issues of Ethics in Today's Agricultural Landscape
New Directions in the Humanities Conference, Chicago, IL, June 2016

Food Sovereignty as a Catalyst for Repositioning Informal Urban Labor Markets
Twelfth International Conference on Environmental, Cultural, Economic & Social Sustainability, Portland, OR, January 2016

Smith, Leopold, and Sustainable Agriculture: Imagining Today's Ethical Human
Conference on Critical Geography, Lexington, KY, October 2015

Regional Food Systems: A Case of Chicago
University of Illinois at Chicago, Urban Food Systems Course, October 2015

FELLOWSHIPS AND AWARDS

Humanities Without Walls, "The Work of the Humanities in a Changing Climate" Research Challenge Recipient, 2017-2020, $146,990, ($3,900 for my research)

Institute for Environmental Science and Policy, UIC, Predoctoral Fellow, 2016-2017, $7,500

Graduate Scholar Award, 2016, New Directions in the Humanities Conference

Graduate Travel Award, Department of Urban Planning and Policy, UIC, 2016 and 2018

PROFESSIONAL EXPERIENCE

Alliance for the Great Lakes – Chicago, IL
Community Resilience Fellow, Building Community Resilience Division, January 2018 to December 2018

Liberty Prairie Foundation – Grayslake, IL
Research Assistant, Food, Farms, and Environment Program, August 2015 to December 2016

Urban Canopy – Chicago, IL
Farm Worker, April 2016 to August 2016

Openlands – Chicago, IL
Research Assistant, Planning and Policy Division, May 2015 to December 2015

Rustic Roads Farm – La Fox, IL
Farm Worker, April 2013 to June 2015

Neighborhood Housing Services of Chicago – Chicago, IL
AmeriCorps VISTA, Neighborhood Strategy and Planning Division, August 2011 to December 2012

Department of City Planning – Pittsburgh, PA
Research Intern, Bicycle and Pedestrian Division, May 2010 to August 2010

SERVICE

Political Ecology Working Group Member
UIC, February 2016 to Present

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College of Urban Planning PhD Students Association, UIC, August 2015 to August 2017

Friday Forum Chair
Department of Urban Planning and Policy, UIC, August 2015 to August 2017

President and Beekeeper
MetWest Community Garden, Chicago, IL, January 2018 to Present