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INTERPRETING THE FARM AS A SYSTEM: DIFFERENCES IN WORLDVIEWS AMONG LARGE-SCALE NON-ORGANIC AND ORGANIC FARMERS IN MICHIGAN'S THUMB REGION

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By

Lesley W. Atwood

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ABSTRACT

INTERPRETING THE FARM AS A SYSTEM: DIFFERENCES IN WORLDVIEWS AMONG LARGE-SCALE NON-ORGANIC AND ORGANIC FARMERS IN MICHIGAN'S THUMB REGION

By

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Agrochemicals are the primary tool to manage weeds and diseases on non-organic farms. These chemicals can disrupt microbial communities and increase pathogenic fungi perpetuating the use of these products. Cover crops and crop rotation are tools organic farmers use to manage weeds and diseases. This case study research aims to identify key differences in the worldviews of large-scale non-organic and organic farmers in Huron, Sanilac, Lapeer and Tuscola counties, Michigan and to illuminate how perceptions of the farm as a system relate to preferred management strategies. This case study includes twenty-three semi-structured interviews with non-organic and organic farmers. Characterizations of farmers' worldviews are drawn from their observations of crop and soil health, perceptions of soil quality indicators and agricultural management information channels. The results demonstrate a stark contrast in how non-organic and organic farmers interpret the farm as a system. Non-organic farmers perceive the farm as a linear system where management solutions focus on the individual components of the system. Organic farmers, on the other hand, tend to view the farm as a complex system where solutions involve nurturing the relationships among the system's components. Fostering an appreciation among all farmers with differing worldviews can provide each farmer with new tools and skills which can aid in improving soil quality and crop health on all farms.

In honor of Granddaddy Jernigan, Dr. James Austin Jernigan, who encouraged and supported me to pursue my dreams. You are dearly missed.

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Finally, I must thank my family. Mom, Dad & Louis, the three of you helped me throughout my life get to where I am today. I hope this along with my future endeavours continue to make you proud.

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CHAPTER 1
INTRODUCTION

Understanding ecological interdependence means understanding relationships. It requires shifts of perception that are characteristic of systems thinking – from the parts to the whole, from objects to relationships, from contents to patterns. A sustainable human community is aware of the multiple relationships among its members. Nourishing the community means nourishing those relationships.
(Fritjof Capra, 1996)

Addressing our reliance on genetically modified varieties and agrochemicals has fundamental applied importance for all of agriculture. In 1996, the introduction and rapid integration of genetically modified (GM) varieties in the United States changed agriculture significantly. With these technologies along with new agrochemicals, non-organic farmers were able to replace cultivation with chemical inputs. Glyphosate, a broad spectrum herbicide, quickly became the most readily used chemical due to the widespread availability and planting of glyphosate-resistant (GR) soybean and corn varieties. GR-varieties became increasingly popular in the United States as farmers learned more about the perceived benefits associated with these varieties. GM- seeds are touted for their ability to increase crop yields, efficiently manage pests, tolerate climatic variation, and decrease labor and input costs (Monsanto Company, 2009). Glyphosate is considerably more benign than older herbicides, but it still interacts with the environment (Busse, Ratcliff, Shestak, & Powers, 2001; Fernandez et al., 2009). On May 17, 2010 an editorial in the *New York Times* focused on our growing reliance on GR-varieties and glyphosate and the ensuing herbicide resistant weeds (Rosenthal, Robbins, & Shipley, 2010). This type of article furthers the public's awareness of our dependence on agrochemicals, but does not identify any solutions to eliminate the negative outcomes we experience from using these technologies.

Farmers' reliance on agrochemicals and GR-varieties coupled by their impacts on the environment has contributed to a greater interest in developing alternative farming strategies; organic agriculture is among the most popular. Organic agriculture prohibits the use of GM-varieties and synthetic agrochemicals. Farmers rely on cultivation, crop rotation and healthy soils to ward off weeds and pests. It is a three year process to transition non-organic land to organic, but rebuilding soils can take much longer. Farmers who transition face a steep learning curve as they learn organic methods. Learning these new management strategies may discourage some farmers from transitioning to organic, but for others a difference in worldviews may be the hindrance.

Worldviews are commonly studied in the social sciences, but rarely discussed in the agronomic sciences. A worldview, or paradigm, consists of a framework of ideas and values through which a person interprets and interacts with his or hers surroundings (Pirages & Ehrlich, 1974). Modernism, which is synonymous with an acceptance of science in service to progress, has been the dominant worldview of the global West (Yankelovich, 1991). This utilitarian perspective suggests humans have authority over nature (Gadgil & Berkes, 1991). Industrial agriculture in the United States epitomizes our captivation with the idea of progress. Continued efforts to mechanize agriculture, increase yields and create agrochemicals to remediate disease signify our obsession with progress. "Reigning cultural paradigms can be passed from generation to generation, and if they aren't challenged, they are simply accepted as truth…To change one's paradigm is a dramatic event" (Wessels, 2006). To induce successful change, the first step is to understand the variation in worldviews among the agricultural community.

Even in close-knit rural communities there is a diversity of worldviews. For example, in Michigan's Huron, Sanilac, Lapeer and Tuscola counties, Michigan's Thumb region, large-scale agriculture has been the dominant industry for over 100 years. Eighty-seven percent of the Thumb is cultivated, largely in soybeans (*Glycine max* L.), sugarbeets (*Beta vulgaris* L.), corn (*Zea mays* L.) and winter wheat (*Triticum aestivum* L.), (NASS 2007). With 85% of the land under non-organic management practices where it is common to grow soybeans, corn and sugar beets that are genetically modified to resist glyphosate. Approximately 1.3% of the cultivated area in the region, or 18,500 acres, are farmed organically (NASS 2007). The organic farms do not use GR-seed or glyphosate to manage weeds. Given the close proximity of the organic and non-organic farmers, as well as the agricultural history of the region, studying this community should provide insight into how slight variations in worldviews relates to differences in preferred agricultural management philosophy, strategies and practices.

This research seeks to identify key differences in non-organic and organic farmers' worldviews in the context of:

1) Observations and perceptions of adverse changes in soil quality and crop health related to management strategies.

2) Soil quality indicators the farmers use in the field to identify healthy and unhealthy soils.

3) Preferred communication and information channels farmers access for management advice.

The findings from 23 semi-structured interviews show non-organic and organic farmers' worldviews differ particularly with respect to the way they interpret the farm as a system. Organic farmers view the farm as a complex system while the non-organic farmers perceive it as a linear system. This finding is woven throughout the research including the farmers' observations, management practices and soil quality indicators. The channels through which the farmers acquire management advice differ in that the organic farmers choose experience-based channels and the non-organic farmers utilize expert-based channels. A shared appreciation among farmers with differing worldviews will provide new outlets for the exchange of ideas, methods and skills which can be used to improve both soil quality and crop health on all farms.

CHAPTER 2
LITERATURE REVIEW

Agriculture embodies the intimate links between social and ecological systems. There are, however, two differing approaches to interpreting the farm in this social-ecological system. Some perceive the natural and social systems as complex interwoven systems (Berkes, Colding, & Folke, 2003). There is also a linear systems approach which focuses on individual components of the system (Drinkwater, 2009). The differences in these approaches lead to different perceptions of how a farm works. Complex and linear systems approaches will be discussed within the context of 1) agricultural management strategies and the environment; 2) soil quality indicators and soil knowledge; and 3) the communication channels farmers use to access management advice. The literature begins to reveal a relationship between how the farmer perceives the farm as a system and the ensuing management strategy he or she applies. Linear theory aligns with non-organic agriculture while complex systems theory is the foundation for organic agriculture.

Complex systems theory is counter to conventional theory which perceives the system as a linear system where the individual components are static. The system responds to stimuli in a predictable sequence of events (Wessels, 2006). There are no feedback loops in a linear system. The system, however, can be cyclical. Conventional theory is the basis of non-organic agriculture.

A complex ecological system incorporates non-linear interactions and feedback loops that makes the system unpredictable (Von Bertalanffy, 2006). Feedback loops are described as either positive or negative. Negative feedback maintains the status quo and positive feedback keeps the system moving in the direction it is already going. There are many equilibria in a complex system, meaning its steady state is dynamic. Change within the system, however, can rapidly occur if the conditions reach a system threshold. Predicting these feedback induced changes is rarely possible because emergent properties also exist in a complex system (Odum, 1971). The unexpected changes often occur rapidly without warning. Resilience to change is one example of an emergent property. Resilience is not present when a system is broken into individual parts. The interactions between the components of the system are, therefore, fundamental to this theory (Berkes, et al., 2003). Social systems, although not commonly described as complex systems, can be analyzed under these same principles.

Non-organic agriculture is "characterized by mechanization, monocultures, and the use of synthetic inputs such as chemical fertilizers and pesticides" (Eicher, 2003). The Sprengel-Liebig Law of the Minimum, in which crop yields are proportional to the limiting nutrient, is a basic tenet of non-organic agriculture (Heckman, 2006). Agronomic science, historically, has abided by this tenet through its emphasis on crop nutrient requirements.

Non-organic agriculture radically changed in 1996 when genetically engineered varieties became commercially available. Genetically engineered, or genetically modified (GM), crops undergo alterations to their DNA to make, modify, improve or develop the crop for production and management purposes (NASS 2007). GM-varieties undergo gene cloning or protein engineering to produce varieties with preferred traits whereas hybrids are cross pollinated to create an offspring with preferred traits. GM-varieties of soybeans, corn, cotton and sugarbeets, are widely used by non-organic farmers today. The most widely grown GM-varieties are the glyphosate-resistant (GR) varieties. These are resistant to glyphosate, the main ingredient in Roundup® ready herbicides (Dill, 2005). GM-varieties became increasingly popular in the United States as farmers learned more about the perceived benefits associated with their use. These included increased crop yields, tolerance to climatic variation and decreases in labor costs (Monsanto Company, 2009). In Michigan, for example, the percentage of GM-soybeans planted increased from 50% in 2000 to 87% in 2007 (ERS, 2009). In contrast, organic agriculture forbids the use of GM-varieties and upholds the Law of Return (Heckman, 2006).

Sir Albert Howard, the pioneer of organic agriculture, believed a farm system is sustainable only if it abides by the Law of Return. Under this law, the farm is viewed as a open system where there are no agricultural wastes. All crop and animal residues are composted and used to improve soil fertility and increases organic matter (Howard, 1943). The concepts Howard presented in 1943 still resonate through the organic agriculture community and exemplify its adherence to complex systems theory. Organic agriculture "promotes the use of renewable resources and management of biological cycles to enhance biological diversity, without the use of genetically modified organisms, or synthetic pesticides, herbicides, or fertilizers" (Eicher, 2003). The premise of organic agriculture is based on a holistic approach where the farm system is in a state of dynamic equilibrium and the farmer strives to optimize the desired biological relationships (Harwood, 1990).

Strategies for non-organic and organic agricultures are grounded in divergent worldviews (Beus & Dunlap, 1990). Non-organic agriculture emerged out of the dominant social paradigm based on progress, faith in science and control over nature (Pirages & Ehrlich, 1974; Wessels, 2006). Organic agriculture emerged as a counter movement to this dominant paradigm. Organics is grounded in holism, decentralization and the balance of nature (Beus & Dunlap, 1990; Drinkwater, 2009). With different paradigms, comparative studies between these strategies often end in conflict and debate because of the underlying beliefs and values associated with each perspective. Beus and Dunlap (1990) synthesized six major dimensions that proponents of non-organic and organic (alternative) agriculture readily debate. They found centralization versus decentralization; dependence versus independence; competition versus community; domination of nature versus harmony with nature; specialization versus diversity; and exploitation versus restraint as the major points of contention.

A common thread, although infrequently discussed, in the non-organic and organic literature is complex and linear systems theory. In the following sets of literature, I incorporate this framework into the discussion to illuminate central differences in these management strategies that relates to a farmer's worldview. I first describe how organic farmers use process-oriented tactics and non-organic farmers use component oriented tactics to manage weeds and crop disease. Second, a review of the U.S. oriented soil knowledge literature raises questions regarding the differences between how non-organic and organic farmers identify healthy soils in the field. Finally, I discuss the heuristic-based and expert-based information channels organic and non-organic farmers, respectively, access for agricultural management advice.

Management Strategies and the Environment

Both organic and non-organic agriculture disturb the natural ecosystem including the biotic community and energy flows in the system (Soule & Piper, 1992). Farmers continually manage the system so it remains at the early stages of succession. At this stage, a greater proportion of system energy is devoted to harvestable biomass and net productivity (Gliessman, 2007).

Recent environmental research shows organic agriculture environmentally out performs non-organic agriculture on numerous grounds including biodiversity (Bengtsson, Ahnström, & Weibull, 2005), soil fertility (Mäder et al., 2002), organic matter content (Reganold, Elliott, Unger, & USDA, 1987) and soil biologic activity (Fliessbach, Oberholzer, Gunst, & Mäder, 2007). These findings are a result of the cultural practices organic farmers use. First, organic farmers rely on cover crops to impede soil erosion, feed soil biotic communities, improve soil structure and build soil organic matter (Snapp et al., 2005). Second, diverse crop rotations are used to aid in both weed and disease suppression (Bond & Grundy, 2001; Van Bruggen, 1995). Scientists do not fully understand all the mechanisms of suppressive soils[1], but there are strong correlations between suppressive soils and active micro-flora and micro-fauna populations (Mazzola, 2002; Sánchez-Moreno & Ferris, 2007). In essence, organic farmers manage weeds and disease mainly through cultural practices geared towards improving the relationships in the system. Organically approved pesticides are used only as a last resort.

Non-organic farmers rely on synthetic fertilizers and pesticides (Bullock, 1992; Pimentel, Hepperly, Hanson, Douds, & Seidel, 2005). The most widely used agrochemical is glyphosate, a broad spectrum herbicide (Woodburn, 2000). Glyphosate

[1] Pest suppressive soils postulates that soil food webs can serve to reduce disease, insect and weed pest populations (Hoitink and Bohem 1999). This is an emerging concept in organic and sustainable agriculture.

was believed to be tightly bound and inactivated by soil colloids and organic matter (Duke and Powles 2008). Recently, however, laboratory studies found unbound glyphosate that is consumed by rhizosphere microbial populations can result in unbalance soil microbial communities (Fernandez, Zentner, DePauw, Gehl, & Stevenson, 2007). The consumption of glyphosate disrupts the community diversity by altering the population growth rates (either increases or decreases) enabling opportunistic species to fill emptied niches. Johal & Huber (2009) also found the long-term use of glyphosate significantly reduces a plant's growth rate, weakens defense mechanisms and nutrient absorption furthering a plant's susceptibility to disease. Overall, these studies suggest glyphosate increases a crop's susceptibility to entomopathogenic fungi.

On non-organic farms, fungal diseases are managed with synthetic fungicides. Pyraclostrobin is a broad spectrum strobilurin fungicide. It is the main ingredient in Headline® and used on GR-sugar beets, GR-corn and winter wheat for protection from fungal diseases like sugar beet leaf spot (*Cercospora beticola Sacc.*) and wheat head scab (*Fusarium graminearum*). This fungicide initially was found to readily form mobile metabolites that decreased in toxicity through photolysis[2] and then consumed by microbes (Bartlett et al., 2002). Pyraclostrobin, however, was recently found to cause adverse affects to soil microbial communities including entomopathogenic[3] fungi and other naturally occurring host specific bioinsecticides[4] (Ragsdale and Koch 2008). Both non-target entomopathogenic fungi and target weeds are controlled with chemicals on

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[2] Light induced decomposition of a chemical.

[3] Fungi that parasitize an insect.

[4] Insecticide made from parts or whole biotic organisms.

non-organic farms, demonstrating that the primary means of management is through a linear system solution focused on etiologic components on the farm.

The methods non-organic and organic farmers use to manage weeds and diseases are grounded in two different perceptions of how the farm operates as a system. Non-organic methods involve mostly chemical solutions meant to cure symptomatic components of the system. This strategy is consistent with a linear systems approach. Solutions geared towards enhancing the relationships and processes between the components of the system are more characteristic of the organic methods. The organic management aligns with a complex systems approach. These differences in management strategies are grounded in the farmers' soil philosophy.

Soil Knowledge

Soil knowledge is extremely complex and multifaceted. It is a mix of knowledge and practice which is difficult to differentiate between (WinklerPrins & Sandor, 2003). Ethnopedology (Williams & Ortiz-Solorio, 1981), a branch of ethnoecology, is "the knowledge of soil properties and management possessed by people living in a particular environment for some period of time" (WinklerPrins, 1999). In practice, farmers use field observations and interpretations of the plants and soil conditions as indicators of soil processes and ecological relationships (Sandor, WinklerPrins, Barrera-Bassols, & Zinck, 2006). Scientific inquiry, on the other hand, focuses on classifications of soils and definitions of soil quality (Doran & Parkin, 1994; Talawar & Rhoades, 1998). Farmers who are close to the land have developed folk taxonomies that differentiate soil taxa (Williams & Ortiz-Solorio, 1981). Much of this literature is currently devoted to indigenous communities in underdeveloped locales (Onduru & Du Preez, 2008; WinklerPrins & Barrios, 2007).

Romig *et al.* (1995) and Cornell University's Soil Health Program (2007) are among the few applications of this field of study to farming communities in the United States. Romig et al. (1995) provides an overview of their work which examines how farmers in Wisconsin assess soil health. They developed a soil health scorecard based on an interpretative framework of farmers' knowledge of soils (Garlynd, Romig, Harris, & Kurakov, 1994; Romig, et al., 1995). Twenty-eight farmers in Wisconsin, both non-organic and low-input[5] cash grain and dairy farmers, were interviewed. Interview transcripts were coded for 97 soil health properties as well as frequency and sequence discussed. The soil quality attributes were then ranked and synthesized into a scorecard. Farmer responses were broad; they included soil, crop, water and animal properties. The top ranked properties include soil organic matter, crop appearance, soil erosion and earthworms. Romig *et al.* (1995) found the farmers interviewed rely mostly on sensory observations when judging soil health. Farmers turned seemingly quantitative data, like soil test results, into qualitative descriptions. They also found farmers often focus on the practices they believe are benefiting the soil's health (e.g. manures and reduced tillage). The relationship between a farmer's management strategy and his or her soil knowledge is not fully explored in the Romig *et al.* project. If there were key differences between non-organic, organic and low-input farmers' understandings of soil knowledge it could be beneficial to programs like Cornell University's Soil Health Program.

[5] Low-input agriculture aims to reduce the rates of chemical fertilizers and pesticides.

The Soil Health Program (2007) takes the same concepts used by Romig *et al.* (1995), but applied it to 1,500 growers in New York State and the Northeast region. To provide farmers with more technical information of the soil's quality, this program performs Soil Health Tests based on the physical, chemical and biological attributes defined by Doran and Parkin (1994). Physical attributes include, but are not limited to references to water retention, soil texture and aggregate size. Cation exchange capacity (CEC), pH and carbon content are all chemical attributes. The biological attributes consist of microbial biomass, soil respiration and weeds as indicators. Overall, the Cornell University Soil Health Program is making progress in improving the quality of soil throughout the Northeastern region, as well as documenting soil knowledge within the agricultural community. From the published data, it is not evident that this program is actively looking into the relationships between management strategies and soil knowledge. Filling this gap in the research will aid in identifying key, but subtle, differences in farmers' worldviews.

Communication and Information Channels

Information travels through communication channels. These are conduits where information moves from a source to a receiver (e.g. interpersonal and media), (Rogers & Shoemaker, 1971). The source is where a message originates (e.g. personal or institution). Communication channels are limited because no source is unbiased and omniscient. Farmers access multiple channels and sources. These channels are often described as networks or knowledge systems.

Knowledge systems are mental constructs that people develop so they can access information from actor networks to support innovation and learning (Röling and Jiggins, 1998). Agricultural networks often include researchers, extension educators and farmers. Knowledge systems are a part of a person's worldview. Expert and facilitative conceptual frameworks are used to describe the prominent knowledge systems used by farmers (Ingram, 2008).

An expert-oriented framework conceptualizes the advisors as disseminators of information and farmers as receivers (Lyon, 1996; Ward & Munton, 1992). Specialization of knowledge and skills is integral to this framework. Although the farmer is considered a receiver, he or she can develop a favorable or unfavorable attitude toward the advisor leading to distrust and, ultimately, the rejection of advice (Lyon, 1996; Rogers & Shoemaker, 1971).

A facilitative approach is based on mutual interactions and shared understandings (Kloppenburg, 1991; Morgan & Murdoch, 2000; Röling & Jiggins, 1994). The farmer is the expert on his/her own farm and must, therefore, observe and monitor the farm system as well as learn how the farm system responds to stimuli (Roling & Jiggins, 1998). The farmers integrate their experiential knowledge with the information they acquire through interacting with other experience-based advisors. Facilitative knowledge systems are prevalent in the sustainable agriculture movement literature, which includes organic agriculture (Hassanein, 1999). Farmer-to-farmer networks are the primary means by which information disseminates through the movement (Hassanein, 1999; Kloppenburg Jr, 1991; Roling & Jiggins, 1998). Examples of the dissemination of information through expert-oriented knowledge systems, on the other hand, are prevalent in the conventional agriculture literature (Cerf & Hemidy, 1999; Winter, 1997). Many of these studies focus on ways of improving the farmer to advisor relationship including building trust and co-operation (Cerf & Hemidy, 1999; Juntti & Potter, 2002). The types of channels farmers access for management advice ultimately influences their decisions and potentially reinforces their perception of the farm system.

Although the literature describes how farmers use either a complex or linear systems approach when managing their farm. Parallels have yet to be drawn with a single case study. This is one of the goals of this research. By developing the relationship between these literatures, a better understanding of how non-organic and organic farmers' worldviews influence their management strategies will be revealed.

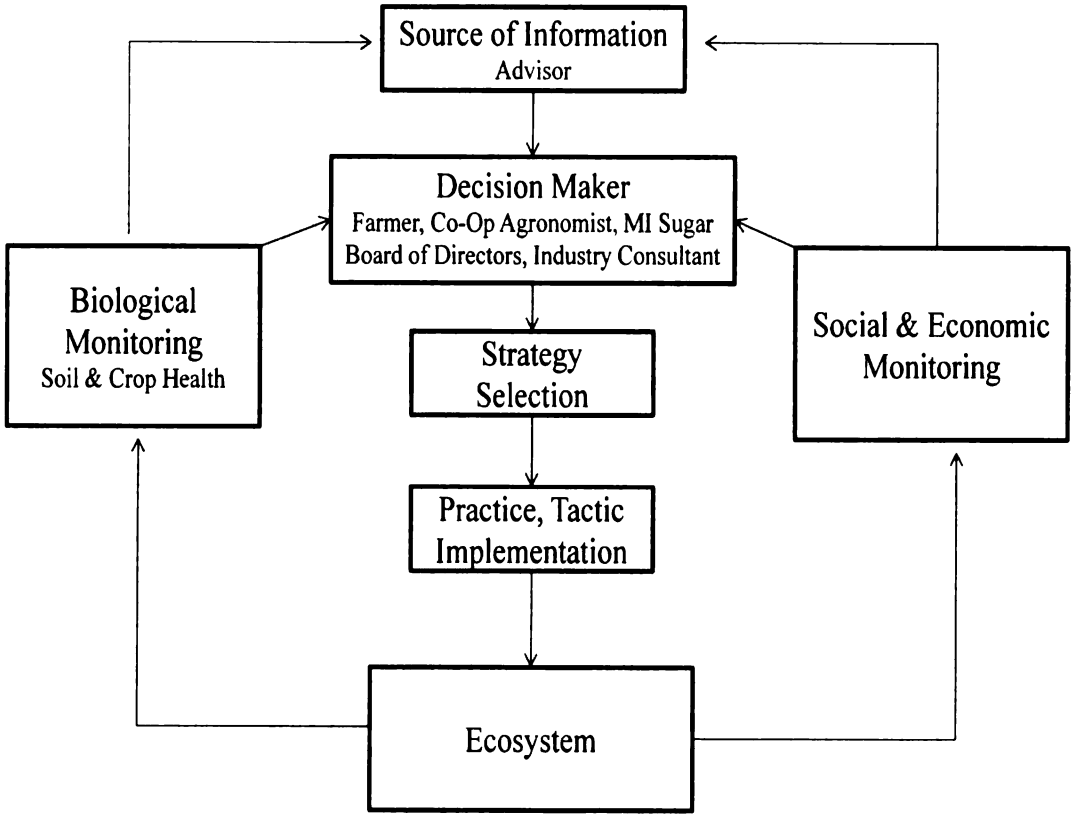
CHAPTER 3
METHODS

Theoretical Framework

Agriculture is embedded in ecosystems. The term *agroecosystem* is used to describe this relationship. "The agroecosystem concept provides a framework with which to analyze food production systems as wholes, including their complex sets of inputs and outputs and the interconnections of their component parts" (Gliessman, 2007). This concept typically focuses solely on the biological components and overlooks the social components of the system.. Since an agroecosystem is managed by people, integrating the farmer's role into this framework is critical to further our understanding of the system. The farmer's role ranges from monitoring the biological processes and parts to assessing the social and economical environments. These roles and the accumulation of knowledge and experience inform his management decision. The conceptual framework for this research is arranged as a complex system and includes the relationships between the farmer, his decisions, the ecosystem and the ecosystem's responses (Figure 2-1).

Ecosystems ecology originated from a complex systems approach and is also the foundation for sustainable and organic agriculture (Drinkwater, 2009). This differs from an agricultural science approach in which the farm is perceived as a linear system where it is common practice to reduce and study each component part of the system (Keller & Brummer, 2002). By acknowledging that both the farm's biological and social components are part of the ecosystem, we can more effectively explore and understand the relationships between a farmer's preferred management strategy and the ecosystem responses.

Figure 2-1. Conceptual framework.



Study Method

A case study is a research strategy used to examine "a contemporary phenomenon in its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 1981). Case studies can be exploratory, explanatory or descriptive of phenomenon. All phenomena are placed within the surrounding context unlike in an experiment where the variables are removed from the context. Data collection can include, but is not limited to qualitative, quantitative or observational. A conceptual framework describes the phenomenon and is organized around the ideas, questions and data collected that are pertinent to the research questions. Modifications to the framework occur constantly throughout the analysis process (Miles & Huberman, 1984). Like the conceptual framework, the research questions are not rigid in that as the study progresses new conceptualizations and questions may arise (Eisenhardt, 1989; Miles & Huberman, 1984). Explanatory case studies result in an explanation of the observed phenomenon derived from within-case analyses. Within-case analyses typically consist of write-ups for each unit of the case which are used to generate insight for the entire case (Eisenhardt, 1989). Single case studies provide insight because "case studies as analytic units should be regarded on par with *whole* experiments" (Yin, 1981).

Qualitative methods are used to answer research questions that require a multifaceted and comprehensive answer (Patton, 2002). Unlike surveys, open-ended questions allows for unpredicted responses and for themes to emerge. However, the quality of these data is dependent on the researcher. Objectivity is not possible with qualitative research or any research for that matter (Dewalt & Dewalt, 2002) because researchers, like all people, have a set of biases and perspectives. To account for this, qualitative researchers strive to make the research both reliable and valid. "Reliability refers to the extent to which results can be reproduced using the same approach under somewhat different circumstances" (Dewalt & Dewalt, 2002). Whereas validity centers on the accuracy and credibility of the participants' accounts with respect to the social phenomena (Huberman & Miles, 1983). Research design should include checks for both reliability and validity. Valid and reliable qualitative data can be used to better understand and refine the conceptual framework as well as better understand all emergent and predicted relationships (Eisenhardt, 1989).

Sampling

A case study approach with qualitative methods was used for this research. A series of topical interviews with closed and open-ended questions were conducted. The topics included agricultural management practices, soil quality indicators, information and communication channels, observed changes in soil quality and observed changes in crop health. A purposeful sampling strategy, which involves seeking information-rich individuals who can provide an in-depth understanding (Patton, 2002), was used to locate large-scale non-organic and organic field crop farmers in Huron, Tuscola, Lapeer and Sanilac counties, Michigan. Within these four counties there are both non-organic and organic large-scale field crop farmers with similar field crops. Non-organic farmers who grew GR-sugarbeets, GR-soybeans and GR-corn were preferred because of their presumed increased reliance on glyphosate to manage weeds. The inclusion of both organic and non-organic farmers allowed for comparisons between the groups with respect to agricultural management practices, soil quality indicators, information and communication channels, observed changes in soil quality and observed changes in crop health.

Data collection consisted of 23 semi-structured interviews which took place between January and April 2010. Two topical interview guides were created (Rubin & Rubin, 2005): non-organic and organic (Appendices A and B). The order in which questions were asked was flexible to accommodate for conversation flow. After the first five interviews, the non-organic farmer interview guide was modified to incorporate emergent themes from the interviews as well as a set of literature on the interactions of glyphosate on soil quality and crop health (Cakmak, Yazici, Tutus, & Ozturk, 2009; Fernandez, et al., 2009; Haney, Senseman, Hons, & Zuberer, 2000). Interviews averaged approximately an hour each. This research included 23 farms: 13 non-organic farmers, two of which practiced non-organic no-till on all their acres; nine organic farmers; and one who farms both non-organically and organically (Total n = 23).

Recruitment of seven of the non-organic participants occurred at the Michigan/Ontario Sugar Beet Research Reporting Session in Bay City, Michigan on January 19, 2010. At the meeting, I met a key informant – a Sugarbeet Advancement technician – who introduced me to four non-organic sugarbeet farmers. Three more meeting attendees consented to this research after I announced my project to all the attendees. Contact information for another non-organic farmer was acquired through a colleague who grew-up on a farm in Huron County. Finally, the recruitment of the organic farmers began with a list of ten farmers a private sector independent consultant gave me. Five of the listed farmers consented to participate in this research. All other participants of this study, eleven others, were identified using the snowball method which involves asking each participant at the end of the interview to recommend other farmers who may be interested in participating.

All interviews were conducted face-to-face at either the participant's home or his farm office. This facilitated access to documents and would feel comfortable participating. Follow-up questions were asked over the phone. All follow-ups and interviews were audio recorded and transcribed verbatim.

Prior to each interview, the participant read and signed an informed consent form indicating that they were voluntarily participating (Appendix C). This document also described the purpose of the research, how they would be protected, and the risks associated with participating. Each consent form included contact information for Dr. James Bingen (advisor), MSU's Internal Review Board, and myself. Each participant returned a signed copy and kept a copy for their personal records. The Human Research Protection Program at Michigan State University (IRB# 09-1174) approved this study. All distinguishing characteristics of the participants were removed to protect their identities.

Data Analysis

All questions eliciting a finite set of responses were counted, and the percent of respondents for each answer calculated. Insight on all numeric responses was provided through emergent thematic content analysis of all transcripts as described by Miles and Huberman (1994). This involved reading each transcript carefully for dominant themes, reducing the data, creating data displays, and then drawing conclusions. Each transcript was carefully read for dominant themes related to each research question and organized using Nvivo8 (QSR International 2009) for both non-organic and organic farmers. Themes were adjusted and combined to reflect new themes emerging across all interviewees with the same management practices (Rubin & Rubin, 2005). Summary statements consisting of multiple themes per research question were created to answer and explain quantitative values. The unit of analysis was the interviewee and the code level was the sentence.

The emergent thematic content analysis resulted in one table for each research objective including emergent themes, definitions, rules, examples and notes (Table 3-1). The emergent themes were used to structure and interpret the data. For the first three objectives, the corresponding emergent themes were used to clarify all quantified data. Themes from these objectives were used to characterize farmer worldviews. All emergent themes are fully described in a table located at the end of each section in the next chapter.

Table 3-1. Application of emergent themes.

Theme	***Definition***	***Rule***	***Example***	***Notes***
Identified across all interviews.	Derived from the transcript data.	How the definition is applied in each transcript.	Excerpt from transcripts that exemplifies the definition and rule.	Comments related to the application of the theme (inclusions and exclusions).

CHAPTER 4
RESULTS and DISCUSSION

All twenty-three participating farmers grew up on a farm in Michigan's Thumb region (Huron, Sanilac, Tuscola or Lapeer Counties). Each farmer purchased or inherited their family's land. Less than half the land they currently farm, however, is owned by the farmer. The participating farmers use a variety of farm management systems including non-organic, non-organic no-till and organic. During the 2009 growing season, farmers cultivated a variety of crops including soybeans, corn, sugarbeets and dry beans (Table 4-1).

Eleven of the participants farm non-organically. They cultivate an average of 2,000 acres. In 2009, the non-organic farmers averaged a four year crop rotation consisting mainly of sugarbeets, soybeans, corn and winter wheat. All grow at least one GR-crop and apply between one (for corn) and three (for sugarbeets) applications of glyphosate on GR-varieties. They also apply between five (for sugarbeets) and none (for corn and soybeans) fungicide applications per season. All ten farmers who grow sugarbeets grow GR-varieties. One of the ten farmers also cultivates nematode resistant varieties. Eight out of nine farmers who raise soybeans, grow GR-varieties. Seven farmers produce GR-corn; one farmer grows edible grade and another uses conventional seed. The corn, soybeans and wheat are sold mostly to cooperative elevators located throughout the Thumb. Each cooperative holds and distributes the product to processors and end users. All sugarbeets are transported by truck, held and processed at Michigan Sugarbeet Company plants located in Bay City, Caro, Croswell, or Sebewaing, Michigan. Less than half of the non-organic participants raised livestock on their farms. Within the past 10 years, however, most of these farmers raised hogs, cattle or dairy cows. They stopped raising animals because of depreciating market prices.

Two of the 23 participants (Table 4-1. Growers 12 & 13) practice non-organic no-till farming. These farmers cultivate an average of 1,350 acres and grow two crops, GR-soybeans and wheat. Both farmers began practicing no-till at least 10 years ago. They spray, at most, two applications of glyphosate each season on their soybean acres. Between one and two applications of fungicides are applied to the wheat crops. They stopped producing corn and edible dry beans because of poor market prices. The no-till farmers claim this practice reduces their need to invest in crop specific equipment, as well as, simplifies farm management. The only major differences in responses between non-organic no-till farmers and non-organic conventional-till farmers were with respect to how these farmers assess soil quality. In all other cases, the non-organic no-till responses were consistent with the non-organic responses. Non-organic no-till farmers, therefore, are grouped into the discussion on non-organic farmers for all results except the section entitled *Soil Quality Indicators*.

Nine participants are certified organic growers. They farm an average of 1,568 acres. Prior to the organic transition and certification process, all but one farmed non-organically. Most of the farmers previously grew sugarbeets. Only two of these farmers grew GR-varieties of any kind prior to organic certification. Before switching to organics, eight of the farmers grew edible varieties, used non-chemical input crops, or practiced no-till. The organic growers received their organic certification between 1991 and 2006. In 2009, these farmers averaged a six year crop rotation which typically

Table 4-1. Grower profiles.

Grower	Management	Organic certification	County	Acres farmed	2009 Crops
1	Non-Organic	NA	Huron	400	Sugarbeets, soybeans, wheat
2	Non-Organic	NA	Huron	620	Sugarbeets, wheat, corn, dry beans
3	Non-Organic	NA	Huron	4500	Sugarbeets, soybeans, wheat, corn, dry beans
4	Non-Organic	NA	Huron	1300	Sugarbeets, soybeans, wheat, corn, dry beans
5	Non-Organic	NA	Huron	920	Sugarbeets, wheat, corn, dry beans
6	Non-Organic	NA	Lapeer	2100	Sugarbeets, soybeans, wheat, corn
7	Non-Organic	NA	Lapeer	920	Soybeans, wheat
8	Non-Organic	NA	Lapeer Sanilac Tuscola	1600	Sugarbeets, soybeans, corn
9	Non-Organic	NA	Sanilac	1100	Sugarbeets, soybeans, wheat, corn, dry beans
10	Non-Organic	NA	Tuscola	3700	Sugarbeets, soybeans (edible), wheat, corn, dry beans
11	Non-Organic	NA	Tuscola Huron	4700	Sugarbeets, soybeans, wheat, corn
12	Non-Organic NoTill	NA	Lapeer	1700	Soybeans, wheat

Table 4-1. *Continued.*

Grower	Management	Organic certification	County	Acres farmed	2009 Crops
13	Non-Organic NoTill	NA	Lapeer Tuscola	1000	Soybeans, wheat
14	Organic	2006	Tuscola	1400	Corn, soybeans, wheat, dry beans, rye, clover, alfalfa
15	Organic	1996	Lapeer	550	Corn (yellow & blue), soybeans, spelt, buckwheat, sunflower, clover, oats, timothy grass
16	Organic	1991	Lapeer	430	Corn, soybeans, spelt, rye, azuki beans, clover, oats
17	Organic	1995	Sanilac	710	Corn, wheat, spelt, dry beans
18	Organic	2004	Sanilac Tuscola	2600	Corn, soybeans, wheat, dry beans, rye, clover, alfalfa
19	Organic	1993	Sanilac Tuscola	2700	Corn (yellow & blue), soybeans, spelt, buckwheat, sunflower, clover, oats, timothy grass
20	Organic	2000	Tuscola	2000	Corn (yellow & blue), soybeans, wheat, dry beans, spelt
21	Organic	2005	Tuscola	1600	Corn, rye, wheat, dry beans, clover
22	Organic	1997	Tuscola	2000	Corn (yellow & blue), soybeans, spelt, dry beans, clover
23	Organic & Non-Organic	2005	Tuscola	1700	Sugarbeets, dry beans, spelt (transitional), wheat, soybeans (organic, non-organic, transitional), corn (non-organic)

included corn, soybeans (clear hilum varieties[6]), dry beans, spelt, and clover. None of the organic farmers use herbicides or fungicides. They all manage all weeds mechanically (e.g. rotary hoe) or with a flamer. All but two of the organic farmers became interested in organic methods for the economic benefit of price premiums. Most of the organic farmers sell their crops to either of two local organic cooperatives, Michigan Thumb Organics (MTO) or Organic Bean and Grain (OBNG).

One participant (Table 4-1. Grower 23) has both non-organic and certified organic fields. In 2009, he grew six crops. One was organic (soybeans). Two were in transition to organic (spelt and soybeans). And five were non-organic (GR-sugarbeets, dry beans, wheat, GR-soybeans, and GR- corn). His responses are kept separate from the organic and non-organic answers because they were a mixture of both the organic and non-organic findings.

Perceptions of Soil Quality

The more complex the network is, the more complex its pattern of interconnections, the more resilient it will be.
(Capra, 1996)

Growers described observed changes in the quality of their soils over the past ten years. Over half (77%) of the non-organic and all (100%) of the organic farmers observed improvements or no change in the quality of their soils (Table 4-2). Non-organic responses differ from the anticipated responses derived from the scientific literature leading to questions about the continual use of glyphosate and soil quality. Farmers were

[6] Clear hilum soybeans are used for in foods like soymilk and tofu because the seed lacks the black speck that other soybean varieties have.

Table 4-2. Grower perceptions of soil quality.

	Management		
Changes in soil quality in last 10 years	***Non-organic**** ***(n=13)***	***Both Organic & Non-organic*** ***(n=1)***	***Organic*** ***(n=9)***
Improving quality	31%	0	89%
No change in quality	46%	100%	11%
Degrading quality	15%	0	0
Unsure of changes	*8%*	*0*	*0*
Farmer explanations for changes (Emergent Themes)	*Reduced tillage* *Less toxic chemicals* *Improved soil fertility* *Temporal scale*	*Less toxic chemicals*	*Soil biology* *Reduced compaction* *Feed the soil* *Temporal scale*

*Includes all farmers who use non-organic management practices (e.g.no-till farmers).

asked to give their rationale for their observations. Different themes emerged from the non-organic and organic responses, which begins to illustrate the relationships between perceptions of soil quality and preferred soil management tactics. Recognizing that there are numerous common threads between non-organic and organic farmers, these results focus mostly on identifying differences between these groups to elucidate points of divergent perspectives and provide insight into the variability of worldviews within the agricultural community.

Non-organic farmers' responses include four themes: 1) *Reduced tillage*, 2) *Less toxic chemicals,* 3) *Improved soil fertility* and 4) *Temporal scale* (Table 4-2; defined in Table 4-3 located at end of section). The non-organic farmers focus on the notion that their current management practices are less harmful to the environment than their previous practices. In other words, the farmers say their current tillage practices, fertilizer rates and agrochemicals disturb the environment less than their previous practices. These practices improve the quality of the soil. Farmers relate these improvements to the adoption of GR-crops and the use of more benign agrochemicals (e.g. glyphosate). This rationale is evident in the following passage in which a non-organic farmer relates the reduction in tillage to his adoption of GR-crops.

> *...because of the GMOs and the use of Roundups we are doing something that makes us better stewards of the soil because we don't have to do something to work up the soils just to get the machinery through it. We only do it if there is a reason to do it now.*

This farmer credits the agrochemicals and GR-varieties for the soil quality improvements he has observed.

Numerous farmers also comment on the reduced toxicity of the agrochemicals used today compared to the agro-chemicals their predecessors used. One farmer said, "Glyphosate is really quite harmless. It's not really deadly poison like some of the other sprays that we use or have used." Glyphosate is often touted as having a short residual in the soil (see Chapter 2); therefore, its environmental impacts are often perceived as minimal or non-existent. Glyphosate is a contact herbicide meaning the spray must contact a weed directly for it to work. Many of these farmers, however, tank mix[7] glyphosate with more persistent herbicides, as recommended by MSUE and the agri-industry representatives[8], to increase the longevity of the product in the soil. For example, farmers frequently mix Canopy™ with glyphosate because it persists in the soil between one and ten months (Sprague & Everman, 2010). Non-organic farmers prefer persistent herbicides because it reduces the number of herbicide applications needed per season.

Non-organic farmers apply products like glyphosate and strobulin fungicides multiple times per season to the same fields. The non-organic farmers did not question if the continual use of these agrochemicals influences the quality of the soil overtime. Upon further investigation, however, it became evident that the chemical make-up of the agrochemicals is not scrutinized by these farmers, other than how well they function. They expect all EPA registered products to be thoroughly tested for any negative consequences prior to it coming onto the market. This trust in the scientific and regulating systems is exemplified in the following comment, "Somebody's already researched all that. So we just go by the label. That's somebody else's job to keep track of that, don't you think?" (This is discussed further in the *Information & Communication*

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[7] This refers to the practice of mixing more than one agrochemical together in a sprayer or applicator.

[8] Tank mixing recommendations were given at the 2009 Integrated Crop and Pest Management Update hosted by Michigan State University Extension.

Channel themes section under the *Faith in agrochemicals* theme). Ultimately, concern for how the agrochemicals interact with the soils is displaced to the experts.

The interactions agrochemicals have with soils and crops are not readily observable to the naked eye. Chemicals and microbial populations are best analyzed through laboratory tests. This means the best opportunity for farmers to observe any potential impacts from the agrochemicals is through their soil test results. Almost all the non-organic farmers, excluding the no-till farmers who interpret their tests themselves, rely on third parties for both the soil tests and test interpretations (refer to *Information & Communication Channel* section). This eliminates the opportunity for the farmer to view laboratory results on chemical or biological changes over time.

Non-organic farmers feel soil quality improvements are related to the new variable rate fertility practices (Theme: *Improved soil fertility*). Variable rate equipment precisely applies nutrients to areas with low fertility. Farmers view this as both environmentally responsible and economical in the sense that it can reduce the farmer's fertilizer bill. Non-organic farmers perform soil tests every 3-4 years and most apply fertilizers according to the tests. Third parties, typically the Cooperative Elevator, custom apply the nutrients using their custom application equipment. The farmers who hire custom applicators say it is economical to outsource fertilizer applications because the variable rate equipment is too expensive to purchase. Distancing the farmer from control over the management of his farm is further discussed in the *Information & Communication Channels* section.

Organic farmers, other than the farmer who farms both organically and non-organically, did not mention variable rate technologies. This is likely due to the fundamental differences in fertility practices between the two groups. Non-organic farmers apply commercial fertilizers composed of nitrogen, phosphorus and potassium that are perceived as readily available to the plant. Organic farmers apply compost, green manures and minerals that are perceived as slowly breaking down and releasing nutrients in the soil. Both sets of farmers use chicken and cow manures to improve soil fertility.

Both non-organic and organic farmers say the process of rebuilding and degrading the soil is slow. This notion often made it difficult for farmers to describe any observable changes in soil quality. As one organic farmer stated, "Nothing in agriculture happens very quick. Especially with soils, everything happens very gradually. I think the main thing is looking at how things have changed in the last 50-60 years and it's very obvious to me that soil degradation has occurred!" As soils change slowly (Montgomery, 2007), evidently it is difficult for farmers to answer this type of question. "And maybe [the soil quality] has [changed], but we don't see it. It's like the little kid you see every six months. 'Man, you've grown a lot.' But if you see him every day it is like, 'are you ever going to grow?' It's like that with the soil." Asking farmers to describe how the soil's quality changes over a 40-50 year period may have provided a more comprehensive glimpse at changes in soil quality with respect to management practices.

Even with inclinations that soil building and degradation are slow processes, most of the organic farmers (89%) describe their soils as healthier since they converted to organic. Four main themes emerged as the organic farmers explained why the soil improved: 1) *Soil biology,* 2) *Reduced compaction,* 3) *Feed the soil* and 4) *Temporal scale* (discussed previously) (Table 4-2; defined in Table 4-3). Organic farmers were keenly aware of the soil's biology (Theme: *Soil biology*). The farmers would often describe the biology of the soil in terms of the soil's odor, "You can smell a soil. If it has a nice pleasant aroma to it you can figure things are happening. If you can't smell anything or it smells kind of sour, then you know that there are problems there." A soil's smell was nearly absent from the non-organic descriptions of soil health (refer to *Soil Quality Indicators* section). This is a striking difference between organic and non-organic farmers in the sense that the organic farmers highly regard living soils while the non-organic farmers focus more on soil fertility. Organic farmers relate the living soil to the biologic activities needed to mineralize and release nutrients and make them available to the plants at the appropriate times.

A living soil is fundamental to the organic farmers' management strategy, and "feeding the soil" is critical to keeping it alive. This concept was fundamental in Sir Albert Howard's book, *An Agricultural Testament* (1943), where he first describes the basics of organic farming. The organic farmers drew parallels between healthy soils and healthy plants as demonstrated in the following passage. "And the theory there is that if you have your soils in fairly good shape and you have a healthy plant, then you're not going to have insect problems" (Theme: *Feed the soil*). Through feeding the soil this farmer feeds the soil biotic community which is essential to two of the emergent properties, suppressive soils and soil resilience, he relies upon for a healthy farm system.

The introduction of cover crops and reduction of heavy machinery also improves the soil's quality. Organic farmers say these two practices, along with diverse crop rotations, improve the soil's structure by reducing soil compaction (Theme: *Reduced compaction*). One farmer who recently stopped growing sugarbeets and now farms organically said, "The soil is a little bit easier to till already. But we've seen a couple dramatic changes in the fact that we're planting clover. So a couple of our fields have seen a clover a couple times in our rotation. And we're not raising sugar beets so we've lessened the compaction considerably." All organic farmers use cover crops in their crop rotations. This differs from most non-organic farmers who have interest in cover crops and have yet to integrate them into the rotation. Cover crops are not only perceived as improving soil structure, but they also function as soil organic matter builders and food for the soil biotic communities.

Overall, organic farmers are primarily concerned with soil health because they benefit from the emergent properties of the system like suppressive soils. Non-organic farmers focus primarily on mechanistic improvements and reduced toxicity of chemicals because they are perceived as less harmful to the soils and surrounding environment. The farm management plans these farmers use differ in that the non-organic farmers manage individual components of the system and the organic farmers foster the processes of the system. These results begin to illustrate some of the difference in worldviews between non-organic and organic farmers.

Table 4-3. Rules applied to text for soil quality emergent themes.

Theme	***Definition***	***Rule***	***Example***	***Notes***
Reduced tillage	Agrochemicals (e.g. glyphosate) allow farmers to reduce their tillage practices which improve the physical attributes of the soil.	A farmer says that the agrochemicals he uses allows him to reduce his tillage frequency which improves the quality of his soil (e.g. tilth, structure).	Non-organic Farmer: We used to work the ground. Work it, work it. To control the weeds. Now we don't have to do so much tillage and I believe that benefits our soil health.	GR-crops are also included here.
Less toxic chemicals	New agrochemicals are less toxic, require fewer applications, and have shorter life-spans in the soil than older agrochemicals. This change improves the quality of the soil.	A farmer relates the lowered toxicity, reduction in applications and shortened half-life of the chemicals he uses to improvements in soil quality.	Non-organic Farmer: Round-up is probably the most, the best thing that has happened because there is no soil activity with round-up. So therefore you have no leaching, no ground water contamination, and we are definitely moving away from the chemicals that do that.	Farmers are tank mixing persistent herbicides with the short residual herbicides to increase the longevity of the chemicals.
Improved soil fertility	Improvements in soil fertility practices as described by individual farmers.	All statements related to improvements in fertility practices.	Non-organic Farmer: Because the manure has been a real good thing for the soil as far as building it up and also the nutrients so we're not going to have that anymore so we'll be taking a good look at cover crops.	This often includes variable rate technologies and the adoption of GM-crops.
Temporal scale	Soil rebuilding is a slow process.	The farmer says it takes a long time for soils to change and/or comments on the gradual changes of the soils.	Non-organic Farmer: I think maybe what I'm doing might build up the organic content, but from what I can recall when I was in school and things that I've read I think it takes just a horrendous amount of years to build up organic matter if I'm not mistaken.	This includes people who have a suspicion the soils are changing but they are not able to readily observe these changes.

Table 4-3. *Continued.*

Theme	***Definition***	***Rule***	***Example***	***Notes***
Soil biology	The presence and role the biotic community plays in soil health.	Farmer says that soil biology is an indicator of soil health and central to maintaining healthy crops.	Organic Farmer: When I'm in the field, normally the smell of the soil will tell me if it's healthy or not. I would call it an earthy smell.	This includes any comments related to soils with an earthy smell which is an outcome indicator of a live soil.
Reduced compaction	Compaction is reduced due to changes in the farming program.	Famer describes management practices that improve the structure and compaction of the soil.	Organic Farmer: I think the tilth has improved. The ground seems easier to till. I would say that it absorbs water better, the tile are probably working better in lieu of the lack of compaction.	Examples include: Introduction of cover crops and the removal of heavy machinery.
Feed the soil	Centered on soil health and how efforts to build the soils results in improved soil quality.	When a farmer states he makes efforts to feed the soil rather than feed the crop which includes building organic matter and balancing of nutrients.	Organic Farmer: Okay our OM is 3.5%, 4, 3.3, 3.4% and we've come up because when we started we were at 2.4%.	This theme differs from Soil Biology in that it focuses less on biologic activity biology and more on overall health which also includes physical and chemical attributes.

Crop Health Observations

Predictability and control lie at the heart of our reigning notions of progress. Our leaders believe they can control the future by constantly adjusting the parts. Technological advances are touted as the means to control one day those things that we can't control right now, allowing progress to continue.
(Wessels, 2006)

In the past ten years, the non-organic farmers saw an increase in fungal disease while the organic farmers observed a decrease in fungal disease (Table 4-4). Non-organic farmers perceived a higher rate of fungal disease (92%) than organic farmers (67%). None of the non-organic farmers observed decreases in fungal disease. Non-organic farmers specifically say they saw increases in fungal disease, mostly on sugarbeets (leaf spot: *Cecrospera beticola Sacc.*) and wheat (headscab: *Fusarium graminearum*). To aide in explaining these stark differences, farmers also explained why they thought their farm was experiencing increasing or decreasing rates of fungal disease. All answers were separated by the farmer's management practices, organic or non-organic, and emergent themes were compiled (Table 4-5).

Non-organic farmers frequently prefaced their observations by stating they only recently learned how to identify and recognize the signs and symptoms of fungal diseases (Theme: *Education*). One farmer described how his father managed fungal diseases by saying, "I don't know. A lot of these diseases we didn't know we had then, I guess." Non-organic farmers frame their observations in this manner because research on fungal diseases is relatively recent[9], and fungicides were not readily available or recommended until the 1970's. Many of these farmers learn about pathogenic fungi and fungicides at

[9] For the past 25 years MSU has had either a field crop plant pathologist who did not communicate with the farmers (for 20 years) or no field crop plant pathologist at all (last 5 years).

Table 4-4. Grower perceptions of fungal disease incidence.

Perceived changes in fungal disease occurrence in last 10 years	**Management Systems**		
	Non-organic* *(n=13)*	***Multiple Systems*** *(n=1)*	***Organic*** *(n=9)*
Increase in disease	92%	100%	0%
Disease constant	7%	0%	44%
Decrease in disease	0%	0%	67%
Farmer explanations of changes **(Emergent Themes)**	*Increased foliage* *Susceptible varieties* *Obsolete (non-GM) varieties* *Education*	*Susceptible varieties* *Obsolete (non-GM) varieties*	*Crop rotation* *Healthy soils*

*Includes all farmers who use non-organic management practices (e.g.no-till farmers)

MSUE's winter meetings and summer field days (discussed further in *Information and Communication Channels*). Most all of the non-organic farmers remember the first time they saw a sprayer on a tractor or a crop-duster fly overhead. On average, these farmers have 35 years of farming experience. Their observations and explanations stem from this experience. The following themes emerged from their responses all of which relate to changes in production practices and varieties. First, increases in fungal disease are a product of increases in foliage or narrow rows (Theme: *Increased foliage*). Bushy plants are more susceptible to disease because "...as you move things closer together there's less air movement and usually air movement tends to dry [things up]. Usually a plant that stays damp for an extended period of time is where diseases tend to spread from one plant to the other. All your mold and mildews get started growing." Increased foliage on plants is likely a product of either the variety or over application of nutrients during vegetative growth (Sinclair & Horie, 1989). Farmers are inclined to plant more seeds per acre as they strive for higher yields. Narrow row systems, however, reduce air circulation through the field, creating a suitable environment for pathogenic fungi development. Another potential contributing factor is the reduced amount of soil aeration in the non-organic fields. As previously noted, non-organic farmers have reduced their tillage practices which may allow soil moisture to accumulate creating a micro-environment suitable for pathogenic fungal development.

Non-organic farmers also have concern with the vigor and overall health crops, especially the sugarbeets. The farmers say sugarbeets exhibit the greatest rate of fungal disease increase. "Increased leaf spot in sugarbeets is newer[10]. Different genetics in the crops increased the sugar percentage. Whenever you increase something, something else has to give" (Theme: *Susceptible varieties*). Farmers wonder if the breeders are focusing solely on sugar content and yields, which depreciates the seed's ability to resist disease. "You can't buy the good traits in corn [sugarbeets or soybeans] without buying the Roundup Ready stuff." In 2009, sugarbeets farmers choose from 20 industry approved sugarbeet varieties, eleven of which were GR-varieties (Michigan Sugar Company, 2009). All sugarbeet farmers interviewed chose glyphosate-resistant varieties. One farmer uses a nematode resistant variety in some of his fields. "Well in the sugarbeet industry, everybody went this way; I don't think there's conventional seed out there" (Theme: *Obsolete varieties*). These farmers feel there are relatively few seeds to choose from that offer both high yields and disease resistance which compromises the overall health of their farm system.

While non-organic farmers view their fungal disease problems as a combination of their production practices and the new varieties, organic farmers relate the lowered rates of disease on their farms to production practices and crop rotations. As previously mentioned, the organic farmers average six crops in their rotation (range: 4-8 crops). Organic farmers say one benefit of a diverse crop rotation is the suppression of soil borne diseases (Theme: *Crop rotation)*. They also value the cyclical interactions between the crops, "Without the grain we wouldn't have the clover which means we wouldn't have the nitrogen for our corn. But without the beans, we wouldn't be able to plant the grain. It's a cycle." The exchange of nutrients between crops proves to be important to organic

[10] MSU currently has a sugarbeet pathologist who meets with farmers regularly, but believes in the chemical control paradigm.

farmers. They also find that by "pay[ing] attention to the relationship of one plant species to the next [they can avoid] setting yourself up for a problem," including disease and pest problems (Theme: *Healthy soils*). Organic farmers are encouraging system processes that they perceive as benefiting the crops. Along with the expected benefits of their management practices (e.g. good soil fertility and structure) are emergent properties like suppressive and resilient soils.

Overall, the organic farmers saw decreases in crop fungal disease which they believe is a product of diverse crop rotations and healthy soils. Improving and maintaining healthy relationships between system components is the strategy these organic farmers use to decrease pathogenic fungal disease in their crops. The non-organic farmers saw increases in crop fungal disease which they believe is a product of bushy crops, narrow row spacing and susceptible varieties. Efforts to remedy this include increased applications of fungicides, new varieties and increased row spacing. These farmers strive to improve their crops by focusing on curing symptomatic components of the system.

Table 4-5. Rules applied to text for fungal disease incidence.

Theme	***Definition***	***Rule***	***Example***	***Notes***
Education	Learning about crop pests and diseases enabled farmers to identify pest signs and symptoms in the field.	Farmer states he is able to identify and remedy crop pests and diseases that he previously did not know about.	Non-organic Farmer: I would say that I notice head scab more however I would have to assume in a lot of years gone back I probably didn't recognize the fact that it was there. So I think I'm a lot more aware of what's out there.	This includes increased awareness and previous lack of awareness of diseases and pests.
Increased foliage	Relationship between increased foliage per plant, acre, or rates of fungal disease in the crop.	Farmer explains the cause of fungal disease on his farm is due to the bushy plants he grows, the close spacing of his plants, or poor aeration in the fields.	Non-organic Farmer: I think our crops are more lush than they used to be. We grow better crops. We've got more vegetation on every ground than we've had. When you have vegetation moisture you're going to have fungal issues or mold issues that you need to control…As things get closer together you have more problems.	This also includes efforts to minimize bushy plants for fear of increased fungal disease.
Susceptible varieties	The varieties planted today are more susceptible to disease and less vigorous than ever before.	Farmer questions the vigor and/or the health of the varieties he grows today as compared with the ones he used to grow or his father once grew.	Non-organic Farmer: We have been trying to breed our crops for better yields, better yields and better yields and in the mean time the breeders aren't paying attention to the diseases. It's kind-of like you can't have both so they're pulling it over here while at the same time it's got this weakness in it instead.	Vigor refers to seedling emergence out of the soil and resilience to variable weather.
Obsolete (non-GM) varieties	The non-GM varieties lack the new genetics for increased yields that the GM-varieties have.	Farmer states that he must buy GM-seeds to get the best yields because no new research is going into the non-GM varieties.	Non-organic Farmer: We don't buy conventional seed because it's kind of out dated, but you can still plant it. No new technology is put towards it. If you want big yields you buy GMOs.	

Table 4-5. *Continued.*

Theme	*Definition*	*Rule*	*Example*	*Notes*
Healthy soils	Maintaining a healthy soil improves crop health.	The farmer relates viable or balanced soils with improved crop health or decrease in pests.	Organic Farmer: Decreased [fungal disease]. Because our soils are healthy, which all boils back to a tight rotation and keeping our mineral levels high enough in our soils.	This does not include fertility focused soil management practices.
Crop rotation	A diverse crop rotation improves soil and crop health.	The farmer comments on the benefits or complications to soil and/or crop health from a diverse crop rotation.	Organic Farmer: Paying attention to the relationship of one plant species to the next and not setting yourself up for a problem. Non-organic Farmer: But I think a lot of that [disease] is just because we've grown beets too close in rotation for too long.	This includes nutrient cycling and suppression of pests.

Information & Communication Channels

Vibrant community is essential. If the community is fragmented into isolated groups and individuals, the diversity can easily become a source of prejudice and friction. But if the community is aware of the interdependence of all its members, diversity will enrich all the relationships and thus enrich the community as a whole, as well as each individual member. In such a community information and ideas flow freely through the entire network, and the diversity of interpretations and learning system - even the diversity of mistakes – will enrich the entire community.
(Fritjof Capra, 1996)

Information disseminates through communication channels such as interpersonal and media (Rogers & Shoemaker, 1971). The private sector channel includes all enterprises not run by state or federal agencies that collect profits. These channels are financially invested. Public sector channels, on the other hand, include all entities run by the state or federal agencies. Cooperatives are "a special type of business firm owned and operated for mutual benefit by the users (member-patrons). Actual management is by salaried professionals. The interests of the members are represented by an elected board of directors" (Rhodes, 1983). All communication channels are limited because no person is unbiased and omniscient. Therefore, when a farmer seeks information or advice for a particular problem from a single channel, the information he receives and ultimately his solution options will be limited. When a farmer synthesizes information from a diversity of channels, he is more likely to identify potential solutions and tailor it to a specific problem. The following section describes the communication channels utilized by farmers. It is divided into the private, public and cooperative sectors. How these channels influence a farmers' decision is also discussed. Throughout the following discussion, the farmer who has both non-organic and organic fields is included with the respective group, but his responses are displayed separately in Table 4-6c to show how his communication channels varied depending on his management strategy, organic or non-organic.

Ninety-two percent of non-organic farmers mentioned Michigan State University Extension (MSUE), part of the public sector, as their primary channel of information (Table 4-6a). Most of these farmers, however, do not meet with MSUE educators on a regular basis. As one farmer explained, "I very seldom talk to a county agent. They seemed to be quite unreliable when I started farming. Maybe they're better now, but they're not really set up for specific questions." Farmers primarily interact with MSUE by using the *2010 Weed Control Guide for Field Crops* (Sprague & Everman, 2010) which provides details for herbicide, fungicide and fertilizer rates. Farmers also attend research meetings where they accrue restricted-use pesticides (RUPs) points. Winter grower meetings and summer field days are typically focused on non-organic variety trials, chemical pest management strategies and potential new pests (personal observation). There are very few if any research reports that venture beyond managing the individual components of a farm.

The sugarbeet affiliates, consisting of MSU (public), Sugarbeet Advancement (public and private hybrid sector) and Michigan Sugar Company (private cooperative), were the second most mentioned communication channel (76%). While discussing sugarbeet advisors, the farmers grouped these three organizations together. The farmers were more interested in information related to sugarbeets than institutional frameworks. All three of these organizations are bound by the production practice parameters set forth by the sugarbeet industry. The parameters are passed onto the farmer, and they include approved seed varieties and agrochemicals. The cooperative agronomist recommends fertility rates and agrochemicals to the farmers. All sugarbeets must be produced by the industry's standards. The agronomist's recommendations are stricter, and often more expensive, with regards to fertility rates and agrochemical applications. Therefore, if the farmer abides by the agronomist's recommendations he will receive a price premium. The primary ways farmers interact with these organizations is through local Michigan Sugar fieldman and sugarbeet website, yearly meetings and BEETcast™. All of these provide the farmer with up to date sugarbeet production protocols. BEETcast™, however, is actively used throughout the growing season because it calculates disease severity levels (DSVs) and informs farmers when *Cercospera beticola Sacc*., leaf spot, is prone to develop (Weather Innovations Incorporated, 2007). BEETcast™ is broadcasted on its own monitor to all subscribers. All ten interviewed sugarbeet farmers subscribe.

> *We use the BEETcast™... It's actually on the Michigan Sugar Company website and based on temperature and humidity conditions you will accumulate points and when you accumulate so many points now it's time to spray. And it's different in every [area]. Our area is typically one of the spot areas where the Cercospera is a little bit worse. And so based on historical perspective that model is designed to push us to spray a little bit sooner than some of the areas where it's not usually seen as intense.*

Sugarbeet farmers depend on BEETcast™ when judging whether or not a fungicide application is appropriate (Theme: *Lifts burden; Faith in agrochemicals*). Many of the farmers appreciate BEETcast and other predictive models because it eliminates the fear of unnecessarily applying fungicides, which are expensive.

The farmers perceive the fungicides as necessary to prevent pathogenic fungi, but the effectiveness of many of the products is unclear.

> *You know you're always looking for stuff, I know we went to spraying the wheat in the last few years, but it seems like that has helped us a lot with some of the diseases on the wheat. On the beans, that's still up in the air. This year I still plan on spraying and running some checks again, but if I don't see results.* [Theme: Farmer initiative] *One of my friends, he really*

believes it's variety selection and I almost think he is right. When it comes to beans if you get one that is healthy from the get go it doesn't need fungicides to help it out. It's got the plant health to get through to make the yields. Corn we have tried fungicides on corn we didn't see any results on it. You know a bushel, bushel and a half, that's not economically feasible. You might as well take that bushel loss.

As this farmer's experience portrays fungicides are not always effective tools. This is partly due to the lack of breadth of pathogenic fungi research. Some fungal pathogens found in field crops today are not currently identified at the species level[11]. The fungicides, therefore, are not species specific and may be ineffective on some fungi. The communication channels these farmers utilize, however, continue to promote fungicides as the solution because they are directly applied to the symptomatic component of the system.

The next two channels non-organic farmers frequently consult are Cooperative Elevators (69%) and private sector representatives (69%). Both of these channels are part of the private sector; both sell agricultural products. Cooperative elevators also store and market commodities. The Cooperative Elevator Company is a private cooperative that has served Michigan's Thumb region since 1915. It has approximately 900 member/owners. The services the cooperative provides includes agronomy consulting, marketing, storage, processing, seed, feed, fuel, fertilizer, herbicides, and agricultural chemicals (Monsanto Company, 2009). The private sector representatives also sell agrochemicals, seeds and fertilizers. They are often affiliated with chemical, seed or fertilizer companies. Since each company is organized differently, a farmer maybe in correspondence with a salesman, consultant or researcher on a regular basis.

[11] Correspondence with Dr. George Bird, Department of Entomology, Michigan State University.

These channels fill roles or carry out specialized tasks farmers are not able to complete because of time or money constraints. For example, chemical salesmen are paid to research and learn the ins and outs of their company's newest products. The salesman's ability to explain to a farmer how he will benefit from the product and why the product is better than the competitor's products eliminates the need for the farmer to research the new chemicals available each year. Instead of "spend[ing] days figuring out all of this stuff," the farmer is able to devote his time to other tasks (Theme: *Lifts burden*). Private sector assistance, however, can come with a price. This may be monetary or frustration (Theme: *Cost of advisor*). If a farmer prefers his fertilizers to be variable rate applied by the local cooperative, he will save money by not having to purchase the equipment, but he may become frustrated if the cooperative does not apply the fertilizers in a timely manner (Theme: *Unsatisfactory advisor*). At least three farmers described a similar scenario during this research. Farmers may also find after they become accustomed to a product, the cost for the product dramatically increases. For example, release of GR-sugarbeets was limited in 2008. Sugarbeet farmers who were spraying herbicides approximately five times during a season as well as cultivating around their beets were excited to adopt GR-varieties. These varieties promised reduced chemical applications and higher sugar contents. After one year of growing GR-beets, the technology fees for using the patented varieties began to increase. "Nobody dreamed that it would end up costing us as much per acre as what our weed control programs were before" (Theme: *Cost of advisor*). There was a significant undercurrent of disgruntlement in many of the interviews, particularly when we discussed the monetary cost of these GR-crops.

Table 4-6a. Non-organic growers' communication channels.

Sector	**Communication Channels**	**Non-organic (n=13)**	**Modes of Advice**
Public	MSU Extension	92%	Weed Control Guide for Field Crops † Field Crop and Agrochemical Research Meetings
Public Hybrid Private Cooperative	MSU Sugarbeet Advancement Michigan Sugar Company Fieldman & Agronomist	76%	Regulates Production of Sugarbeet Sugarbeet Research Reporting Sessions Growers' Guide for Producing Quality Sugarbeets‡ Michigan Sugarbeet Variety Trial Results †† Michigan Sugar Company Website BEETcast™ (Disease Warning Model)
Private Cooperative	Cooperative Elevators Agronomists, Fieldmen & Salesmen	69%	Scouts for Pests Agrochemical Custom Applications Soil Tests (Site Specific) & Fertility Recommendations Variable Rate Fertilizer Applications
Private	Private Sector Representatives*	69%	Farm Visits Soil Tests & Fertility Consultations Agrochemical Consultations On-site Seed Trials
Public	NRCS	23%	No-till Management Equipment
Private	Independent Consultant **	8%	Soil Tests
Private	Other Farmers	0	
Private	Educational/ Non-Profit Meetings	0	(not for profit)

*This group includes seed, agrochemical, fertilizer, and machinery salesmen
**These advisors do not sell agricultural inputs, but they provide services (e.g. soil testing).
† (Sprague & Everman, 2010)
‡ (Michigan Sugar Company, 2009)
††(Michigan Sugarbeet Research & Education Advisory Council (REACH), 2009)

Table 4-6b. Organic growers' communication channels.

Sector	Communication Channels	Organic (n=9)	Modes of Advice
Private	Other Farmers	78%	Personal Communications
Private	Private Sector Representative*	67%	Soil Tests & Fertility Recommendations On-site Seed Trials (two strictly organic representatives mentioned)
Public	MSU Extension	44%	Personal Communications with Agent (two agents mentioned)
Private	Independent Consultant **	33%	Soil Testing & Fertility Recommendations (one consultant mentioned)
Private	Educational/Non Profit Meetings	33%	Michigan Organic Conference (MOFFA) Midwest Organic & Sustainable Education Services (MOSES)
Public Hybrid Private Cooperative	MSU Sugarbeet Advancement Michigan Sugar Company Fieldman & Agronomist	0	(Organic farmers do not grow sugarbeets)
Private Cooperative	Cooperative Elevators Agronomists, Fieldmen & Salesmen	0	
Public	NRCS	0	

*This group includes seed, agrochemical, fertilizer, and machinery salesmen
**These advisors do not sell agricultural inputs, but they provide services (e.g. soil testing).

Table 4-6c. Multiple system grower's communication channels.

Sector	Advisors	*Multiple Systems* (n=1)	Modes of Advice
Private	Other Farmers	100%	Personal Communication (Organic advice)
Public	MSU Extension	100%	Weed Control Guide for Field Crops † Field Crop and Agrochemical Research Meetings (Non-organic advice)
Private Cooperative	Cooperative Elevators Agronomists, Fieldmen & Salesmen	100%	Agrochemical Consultations Soil Tests & Fertility Recommendations (Non-organic advice)
Public Hybrid Private Cooperative	MSU Sugarbeet Advancement Michigan Sugar Company Fieldman & Agronomist	100%	Regulates Production of Sugarbeet Growers' Guide for Producing Quality Sugarbeets‡ Michigan Sugarbeet Variety Trial Results †† Michigan Sugar Company Website BEETcast™ (Disease Warning Model) (Non-organic advice)
Private	Private Sector Salesmen*	100%	On-site Seed Trials (one salesman mentioned) (Non-organic advice)
Public (national)	NRCS	0	
Private	Independent Consultant	0	
Private	Educational/Non-Profit Meetings	0	(not for profit)

*This group includes seed, agrochemical, fertilizer, and machinery salesmen
†(Sprague & Everman, 2010)
††(Michigan Sugar Company, 2009)
‡(Michigan Sugarbeet Research & Education Advisory Council (REACH), 2009)

Non-organic farmers adopt chemicals in most cases based on the price of the chemical, the relative ease of application and if it works. To encourage farmers to try new chemicals, company representatives use multiple tactics including awards, freebees and trips. During an interview with a non-organic farmer, we discussed his loyalty to a particular chemical company. When asked why he began working with the company he said, "The salesman was really good. He took us on pheasant hunting trips" (Theme: *Gifts*). Throughout the interviews, farmers told similar stories about their first experiences with a private sector representative and their continued loyalty to the company. Farmers also said they typically change companies only after they are given "great deals" on a competitor's product and they believe they will benefit economically by changing.

The organic farmers did not mention any gifts from the two private sector representatives they consult. Instead, they remarked on the useful information they acquired that was outside the scope of their purchases.

> *We've got a farm back here a half mile and I've seen dry beans that were this wide and this tall with white mold on them. And I mean I saw it. And you know traditionally I think of white mold coming in when the crop is completely canopied and you just can't get that air in there. And in the first year or two we went organic we went up and talked to a guy that's been organic for 15 or 20 years. And we were talking about white mold and this and that and his comment, and I'll never forget this, "if you get white mold in your beans you've got something out of balance. You're not doing things right." And this guy sells micro-nutrients, organic fertilizer. You know he made that comment and two years ago we had some 50 bushel black beans. Probably the best beans we've ever grown conventional or organic. I don't know. We didn't have any white mold in those.*

The organic farmer values the exchange of new information that can be readily used on the farm. In fact, many of the organic farmers were skeptical of the GM-crops and agrochemicals. As one young organic farmer said, "I personally don't know a whole lot about the glyphosate seeds and what they're all doing. In my opinion, I don't think it's needed. Just seeing what we do and what kind of yields we're getting, I don't think GMO crops are a necessity like everybody else thinks" (Theme: *Skeptical of agrochemicals)*. The two private sector representatives that organic farmers communicate with both work strictly with organics. This channel of information, therefore, likely lacks information on agrochemicals and GM-crops.

The most significant difference between the non-organic and organic communication channels stems from the non-organics reliance on agronomical science-based channels and organic farmer's preference for experience-based channels. The organic farmers interviewed utilize other farmers (78%), two private sector organic representatives (67%) and MSUE (44%) the most (Table 4-6b). Seven growers said their primary channel of communication is other organic producers. The following passage was taken from an organic farmer's response when asked who he seeks pest management advice from:

> *Other farmers. We obviously watch our crops ourselves and determine if we have a problem [Theme: Observations]. If we do then we talk to people like [organic consultants]... And once and a while you'll talk to someone in the industry that will offer solutions. But our first recourse is other organic farmers that may be have had the same problems. Or [organic consultants who] consult with a lot of other farmers and often times sees and recognizes problems before anybody else would.*

This case exemplifies how organic farmers prefer to seek advice from multiple people with on-farm experience as well as monitor the farm themselves. One reason organic farmers gravitate towards one another for advice rather than the scientific community is partly out of necessity and partly due to their previous experiences. It is a necessity because there is little organic field crop research currently conducted at Michigan State University[12]. The farmers say there is only one MSUE agent in the state that makes an effort to support organic farmers. Some organic farmers have completely lost faith in MSU and MSUE for these reasons, as well as previous experiences where the farmer felt MSU did not have the organic farmer's best interest in mind. The Michigan Organic Conference put on by Michigan Organic Food and Farming Association is held on MSU's East Lansing campus. This conference is one of the few MSU affiliated events the organic farmers interviewed plan to attend each year. All other MSU winter meetings are non-organically focused so they choose not to attend.

Organic farmers did not mention the Natural Resources Conservation Service (NRCS) as a main channel. This was unexpected because many of the organic farmers participate in the Environmental Quality Incentives Program (EQUIP) which rewards farmers monetarily for using organic practices. The organic farmers may, however, not perceive this relationship as a main source of information because NRCS requires farmers to follow the USDA organic standards. Since the organic farmers already adhere to or exceed the standards the NRCS is not providing new information to them.

Control over how the farm is managed is central to the way organic farmers function. They seek advice through multiple communication channels, but they ultimately synthesize their findings, assess their own situation and then formulate a management plan specific to their problem (Theme: *Observations & Farmer initiative*). Self reliance is key to the strategies employed by the organic farmers. Organic farmers

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[12] At MSU's Kellogg Biological Station there are less than ten organic field crop experiments all of which are focused on seed trials and weed control (www.covercrops.msu.edu/organic/index.html).

value new information, which is why they utilize multiple communication channels, but they are extremely selective in where they get the information and if they use the advice.

These results identify some of the differences between the types of communication channels used by organic and non-organic farmers. Organic farmers prefer ecosystem oriented experience-based channels while non-organic farmers tend to rely on mechanistic oriented expert-based channels. The mutual interactions and shared understandings are the base of the organic facilitative channels (Kloppenburg, 1991; Morgan & Murdoch, 2000; Röling & Jiggins, 1994). In other words, the organic farmers consult advisors with on-farm experience who have knowledge about the interconnected components of the farm. They provide broad strategies for remediating a problem. The non-organic farmers, on the other hand, mainly consult highly specialized advisors who provide narrow tactics for specific problems. Solutions for the symptomatic parts of the system identified which supports the linear systems management approach. Ultimately, the type of communication and information channels the farmer seeks out reinforces his understanding and perception of the farm system.

Table 4-7. Rules applied to text for growers' communication channels.

Theme	***Definition***	***Rule***	***Example***	***Notes***
Lifts burden from farmer	Farmer chooses to rely on an industry advisor to manage some specialized task.	When farmer states the industry representative alleviates a burden or fills a need (e.g. soil testing, fertility management, learning new agricultural technologies)	Non-organic Farmer: I read a lot to keep up with a lot of practices, but in the heat of the battle I've had an agronomist with me my whole career that knows every weed control and chemical book. He has it memorized. <u>If I call him up he knows the answer. I don't have to hunt.</u>	This rule applies to all industry affiliated advisors including co-op agronomists, sugarbeet agronomists and sugarbeet fieldmen.
Faith in agrochemicals	Relies on new agrochemicals to solve pest problems.	When farmer states or implies that he prefers to use agrochemicals to solve management problems.	Non-organic Farmer: Somebody's already researched all that so we just go by the label.	Management practices were included in this theme.
Farmer initiative	Questions private-sector advisors' recommendations; farmer maintains control over the management of his farm.	Farmer dictates how and to what extent private-sector advisors are involved in their management practices.	Non-organic Farmer: And I really believe in on farm testing because you have to find out what works for your farm.	Farmer does not necessarily have faith in or is fully skeptical of agrochemicals.
Gifts	Advisor gives farmer a gift or award.	When a farmer mentions any award, prize, or trip an advisor gives him.	Non-organic Farmer: We had an 18 ton yield, but our sugar content was over 21% and that was their company record. I call it beginners luck, but we got a plaque. Our first year we got jackets and a plaque.	These are signs of persuasion to use certain products.

Table 4-7. *Continued.*

Theme	***Definition***	***Rule***	***Example***	***Notes***
Observations	Farmer scouts and monitors to determine the extent of a problem/pest.	When a farmer says he scouts and/or observes his farm prior to making management decisions	Organic Farmer: I like to be out in my own fields scouting to see what's there.	Private sector representatives that scout are not included.
Skeptical of agrochemicals	Questions the impacts agrochemicals and/or GM-corps have on the farm.	Farmer states that agrochemicals are 1) not the best solution or 2) can cause more harm than good.	Organic Farmer: …the application of glyphosate, although it is promoted as being very neutral and not harmful, does have long lasting effects on soil biology; the ability of legumes to nodulate, and disease levels.	This is often linked with the organic rhetoric.
Cost of advisor	Monetary and emotional costs associated with working with advisors.	When a farmer comments on a monetary or emotional cost associated with working with an advisor.	Non-organic Farmer: <u>They give us a 40 cent bases better if we follow their consultant's recommendations</u>. Non-organic Farmer: On my hundred and twenty five acres of sugarbeets it's $8,600 of [seed] tech fee, for 100 acres. <u>So it's very expensive</u>.	This arrangement can benefit either the farmer or the advisor.
Unsatisfactory advisor	Advisor fails to meet the needs of the farmer.	Farmer comments on a task that an advisor was unable to fulfill.	Non-organic Farmer: I have, I called the elevator many years in a row to do [a soil test] and they never came out to do it.	This also includes recommendations that farmers are not willing to accept.

Soil Quality Indicators

When we observe the environment, we necessarily do so on only a limited range of scales; therefore, our perception of events provides us with only a low-dimensional slice through a high-dimensional cake
(Levin, 1992)

The term soil quality embodies the interactions and balance between the physical, chemical and biological attributes of soil (Doran & Parkin, 1994; Karlen et al., 1997). Romig *et al.* (1995) developed a soil health scorecard for Wisconsin farmers based on their knowledge of soils. Over the past six years, Cornell's Soil Health Program Work Team has developed soil measurements farmers can use to help monitor soil health in both space and time (Cornell University, 2007). The following results build off the Romig *et al.* and Cornell's Soil Health Program work. This research begins to differentiate which visual indicators non-organic, no-till and organic farmers use to assess soil quality, and relates it to their worldviews.

Farmers described the visual cues they use to identify a healthy from an unhealthy soil. Responses were divided into six groups. The first three are components of soil quality; the physical, chemical and biological attributes defined by Doran and Parkin (1994). The second three are crop health, organic matter and no visual indicators (Table 4-8; defined in Table 4-9). Physical attributes include, but are not limited to references to water retention, soil texture and aggregate size. Cation exchange capacity (CEC), pH and carbon content are chemical attributes. The biological attributes consist of microbial biomass, soil respiration and weeds as indicators. Crop health, organic matter and no visual indicators were separated from the three defined attributes for the following reasons. Organic matter is unique because it functions in all three aspects of soil quality, physical, chemical and biological realms. Crop health is not a soil quality attribute, but over half of all farmers use crop health to determine the relative health of a soil. Romig *et al.* (1995) also found soil organic matter and crop health as the top two ways farmers assess soil health. The last category, *No Visual Indicators*, includes responses in which the farmer says he does not use visual indicators. This is significant to keep track of because it may be a sign of loss of soil knowledge in a particular agricultural community.

With the exception of soil organic matter, the results shows little difference between the types of visual indicators non-organic, non-organic no-till and organic farmers use to evaluate soil health (Table 4-8). Farmers from all three groups use physical and chemical attributes to assess the soil in the field: referenced by 92% of non-organic, 100% non-organic no-till and 100% organic. Biological attributes are less commonly used by the farmers to assess soil quality: 54% of non-organic, 100% non-organic no-till and 67% organic. Finally, organic matter content is primarily referenced by organic and non-organic no-till farmers (100%, 50% respectively) and rarely referenced by non-organic farmers (31%). This finding does not mean the non-organic farmers did not acknowledge soil organic matter during the interview. In fact, non-organic farmers frequently mentioned organic matter when describing their soil tests. It was not, however, a common practice to infer a relationship between organic matter content and the quality of the soil. "We rely a lot on soil tests too to get the pH and organic matter and balancing all of that out." Whereas the organic farmers and one non-organic no-till farmer drew strong connections between soil organic matter and soil quality. Most non-organic farmers used crop health as their primary indicator of soil health while organic farmers used it as a secondary or tertiary indicator. The order or ranking of attributes is useful to identify which soil attributes farmers are most familiar

Table 4-8. Soil quality indicators used by growers.

	Management			
Visual Indicators of Soil Quality	***Non-organic (n=11)***	***Non-organic No-till (n=2)***	***Multiple systems (n=1)***	***Organic (n=9)***
Physical Attributes	91%	100%	100%	100%
Chemical Attributes	91%	100%	100%	100%
Biological Attributes	45%	100%	0	67%
Crop Health	63%	0	0	55%
Organic Matter	27%	50%	100%	100%
No Visual Indicators	18%	0	0	0
Emergent Themes				
Feed the Soil	9%	50%	100%	55%*
Feed the Crop	18%**	0	0	0

*Farmer responses were only counted under this theme if Feed the Soil was descriptively or explicitly mentioned. If management practices were included, 100% of organic farmers would fall in this category.

**Farmer responses were only counted under this theme if Feed the Crop was descriptively or explicitly mentioned. If management practices were included, 100% of non-organic farmers would fall in this category.

with, but the depth and breadth of their responses indicates a fundamental difference that is not apparent through a ranking system.

During the interviews, it was readily apparent the organic and non-organic no-till farmers were highly versed when it came to describing soil quality attributes compared with the non-organic farmers. For example, one organic farmer took nine minutes to describe how he determines if a soil is healthy, while the conversation with many of the non-organic farmers involved a four to five word list of indicators. The non-organic no-till farmers often stressed the improved structure and permeability of the soils, which relates to their use of cover crops. The discourse with the organic farmers commenced with soil assessment practices but quickly expanded into a focus on soil development and health. These farmers emphasized the soil's value; something many of the farmers realized they were not cognizant of when they farmed non-organically. "I think we pay more attention to soil now than we used to. We're trying to help the soil not just use it as a pot to grow something in." The decision to provide for the soil and improve the process in which nutrients are supplied to the plant differs from the non-organic methods in which readily available nutrients are believed to be supplied directly to the crop. Half of the organic farmers explicitly used the concept of "feed the soil" during the interviews (Tables 4-8 & 4-9); while the other half put the concept into action with their management practices. For example, when an organic farmer was asked how he managed soil fertility he answered "Green manures, you know, plow downs, clover in the rye, chicken manure. We use some compost, and then just crop rotations." The process of building the soils through the addition of green manures and slow releasing composts is a way of feeding the soil. The farmer knows that the results of the practice are not immediate, but he chooses this practice because he perceives the farm as a system in which nourishing the beneficial relationships between the system components to encourage appropriate system feedback.

Complex systems involve relationships between the parts of a system and the system can feed back onto itself (Odum, 1983; Wessels, 2006). These feedback loops make the system unpredictable. Feedback is described as positive or negative. Negative feedback maintains the status quo and positive feedback keeps the system moving in the direction it is already going. The organic farmer's decision to feed the soil, as opposed to feeding the crop, is an action that acknowledges the farm as a complex system. By encouraging a healthy relationship between the soil and crop, the farmer strives for long term benefits in terms of crop yield and quality. The act of feeding the complex system is unique in that many farmers, including most of the non-organic farmers interviewed, based on the discussion below tend to perceive the farm as a linear system.

In a linear system, the parts always follow the exact same sequences of interactions (Wessels, 2006). A linear system can be cyclical. The system is predictable because it lacks feedback loops. Non-organic farmers frequently perceive and manage their farms with a linear system framework. They are keenly aware of the individual parts of the farm, particularly chemical attributes, and manage those parts intensely. "Feeding the crop" refers to a farmer's goal of providing for a specific component of the system. He anticipates the sequence of processes will proceed in a predictable fashion after he supplies the nutrients. With respect to management practice, this is exhibited in many of the non-organic farmers' meticulous management of nutrient inputs and crop outputs. As one non-organic farmer said,

> *Yeah, just how productive it is. And of course you have to, we do test for numerous different things and it gives the level of it and that's what we go by. Because you're going to plant a crop and it's going to remove so many pounds of this ingredient. And the test will say what you have and what's available. That's a big part of it. What is available like this year, you know.*

This farmer established a benchmark for the minimum inputs required to produce a profitable crop. Since he operates the farm as a linear system, he knows that the process of nutrient absorption to crop yield is a predictable one. And as long as he reaches the nutrient benchmark the system will likely proceed in a predictable fashion.

How each farmer chooses to manage his farm suggests either a linear or complex systems approach to management. Many of the organic farmers viewed the farm as a complex system of interrelated parts where management practices centers on the healthy relationships and the encouragement of appropriate system feedback. And many of the non-organic farmers perceive the farm as a linear system where the parts usually react to stimuli in a predictable manner. Neither of these perspectives is right or wrong, per se, but the differences in how these worldviews relate to management practices is useful to know as we strive for more sustainable agricultural management practices.

Table 4-9. Rules applied to text for soil quality indicators.

Theme	*Definition*	*Rule*	*Example*	*Notes*
Physical Attributes	Physical indicators of soil conditions as defined by Doran & Parkin (1994).	When a farmer describes his soils in terms of its physical attributes.	Non-organic Farmer: I like to see the soil break up nice, mealy they call it.	Examples include: water retention, texture, aggregate size
Chemical Attributes	Chemical indicators of soil conditions as defined by Doran & Parkin (1994).	When a farmer describes his soils in terms of its chemical attributes.	Non-organic Farmer: We rely a lot on soil tests too to get the pH and organic matter and balancing all of that out.	Examples include: CEC, pH, C Content
Biological Attributes	Biological indicators of soil conditions as defined by Doran & Parkin (1994).	When a farmer describes his soils in terms of its biological attributes.	No-Till Farmer: As a no-tiller we do depend a lot on the micro-activities that's going on in the soils.	Examples include: Microbial biomass, soil respiration, temperature, weeds as indicators. The outcome indicators related to smell (earthy, good, alive) are included in this theme.
Crop Health	Crop health is used as an indicator of soil health; as described by Romig *et al.* (1995).	Statements regarding crop color, health, yield, etc. reflect the health of the soil.	Non-organic Farmer: Color of the crop, you can tell by colors if your ground is deficient in something.	Examples include: green, healthy, uniform, lush, dense stand, tall, larger, sturdy, stout, proper color, darker, good crop, lack of green, light green, streaks in field.

Table 4-9. *Continued.*

Theme	***Definition***	***Rule***	***Example***	***Notes***
Soil organic matter	Organic matter is used to determine a soil's health; as described by *Romig et al.* (1995).	All references to organic matter, addition of manures, compost or building the soils up.	Organic Farmer: You've still got to build soils, healthy soils.	Organic matter as high as possible, at soil's potential.
Feed the crop	The soil is a medium for crops to obtain nutrients.	When a farmer says his main goal is to supply the crop its required nutrients.	Non-organic Farmer: So we're basically just applying what we're taking out so you can maintain.	Management practices exemplifying "Feed the Crop" are not counted in Table 3-8.
Feed the soil	The soil is alive. Nourishing the soil is central to having healthy crops.	When a farmer says his main goal is to nourish the soil which will in time feed his crops.	Organic Farmer: These are all visual indicators of soil quality based on your fertility practices, your soil enrichment, soil organic matter practices, your cover crops, compost, manure, the things that feed the soil.	Management practices exemplifying "Feed the Soil" are not counted in Table 3-8.

Worldviews

The web of life is a flexible, ever-fluctuating network. The more variables are kept fluctuating, the more dynamic is the system; the greater is its flexibility; and the greater is its ability to adapt to changing conditions.
(Fritjof Capra, 1996)

The lens through which an individual interprets and interacts with the world is his worldview. This is the foundation of a person's beliefs, ideas and actions. The results of this research show fundamental differences in worldviews between organic and non-organic farmers. To further illustrate these findings, farmers were characterized based on the following six emergent themes: fertility strategy (Feed the Crop or Feed the Soil), pest management practices (chemical or mechanical), opinion of agrochemicals (Faith in or Skeptical of), Communication Channels (Expert-based or Experience-based), soil quality indicators (crop health, physical, biological, chemical, soil organic matter), and systems approach (Linear or Complex). Farmer characterizations were arranged along a continuum based on common perceptions and management practices. The farmers fell into five groups ranging from *Epitome of Non-organic* to *Epitome of Organic* (Figure 4-1). The representation of worldviews is limited because it is based solely on one interview per respondent. Even with this limitation, organizing the data in this manner allows for a more comprehensive understanding of how farmer worldviews translate to preferred management tactics.

The participants grouped at the poles were the most steadfast in their respective worldviews. These individual's management practices and perceptions of the farm as a system were extreme compared with the other 20 growers. One farmer was grouped under the *Epitome of Non-organic* heading (Figure 4-2a). He was placed in this group because throughout his both his management practices and perceptions of the farm

Figure 4-1. Grower worldview characterization continuum.

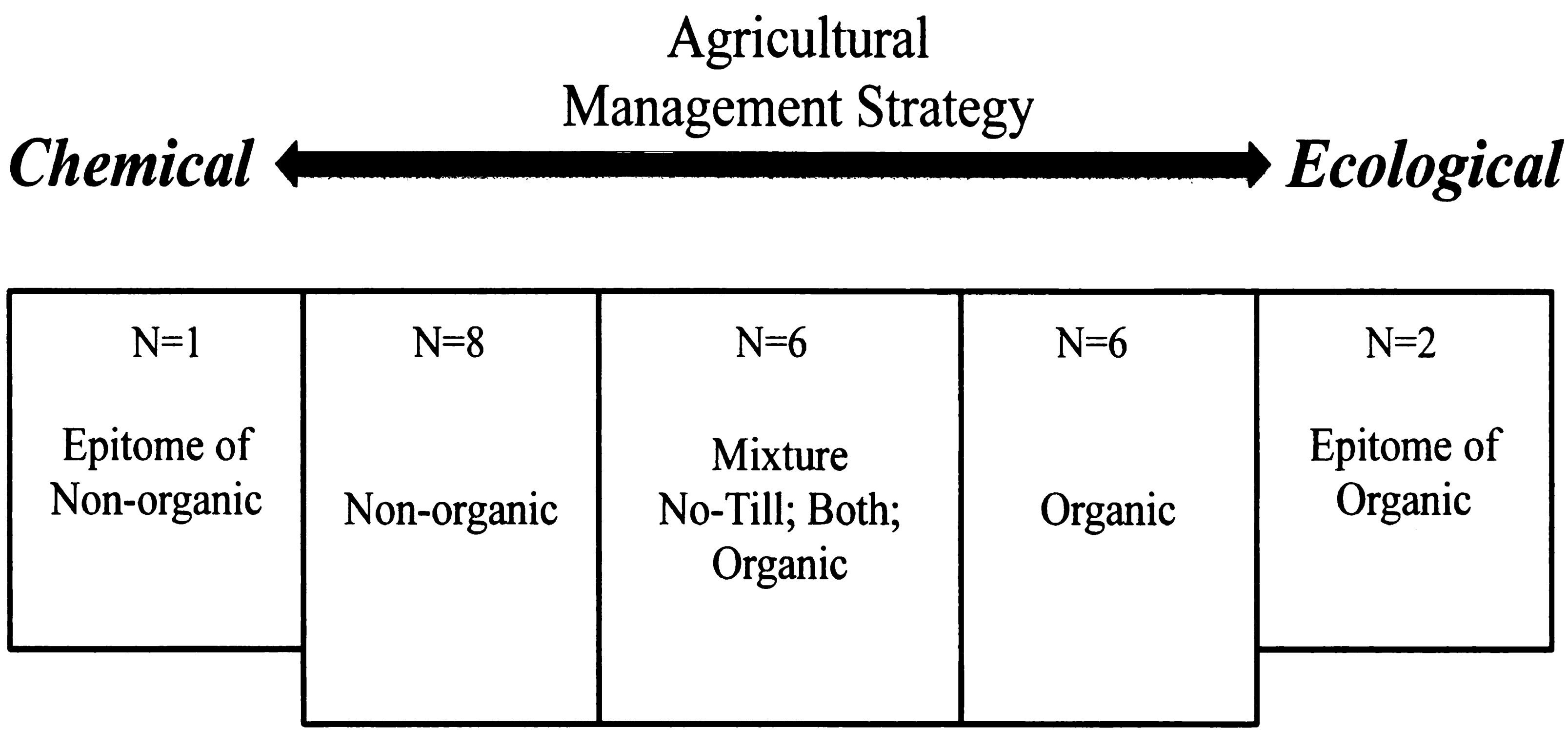

Figure 4-2a. Epitome of non-organic grower characterization details.

Epitome of Non-organic

N = 1

Feed the Crop
Chemical Pest Mgmt
Faith in GM-Crops
Expert-based Channels
Chemical & Crop Health Indicators
Linear Systems Approach

Figure 4-2b. Non-organic growers' characterization details.

Non-organic

N=8

Linear Systems Approach
Feed the Crop
Chemical Pest Mgmt
Faith in GM-Crops
Chemical & Physical Indicators
Expert-based Channels

Figure 4-2c. Mixture growers' characterization details.

Mixture:
No-Till, Both, Organic

N = 6

Linear Systems Approach
Feed the Crop
Chemical Pest Mgmt
Faith in GM-Crops
Chemical & Physical Indicators
Expert-based Channels

Figure 4-2d. Organic growers' characterization details.

Organic

N=6

Complex Systems Approach
Feed the Soil
Mechanical Pest Mgmt
Skeptical of GM-Crops
Biological & Physical Indicators
Experienced-based Channels

Figure 4-2e. Epitome of organic growers' characterization details.

Epitome of Organic

N = 2
Feed the Soil Mechanical Pest Mgmt Skeptical of GM-Crops Experienced-based Channels Biological & SOM Indicators Complex Systems Approach

aligned with the following emergent themes: feed the crop, chemical pest management, faith in GM-crops, expert-based channels, chemical and crop health indicators and a linear systems approach. The following passage illustrates his faith in GM-crops, reliance on expert-based communication channels and use of a linear systems approach:

> ***Atwood**: Has there been a change in the amount of fungicides you use?*
> ***Grower**: Oh yeah. ... I've always used them on the beets since I started growing them. With the sugar beet advancement stuff that started they were telling us to spray this stuff on the beets for the Cecrosperia, leaf spot. So I've been doing that all along. ......Then not only with the leaf spot, but for these last half a dozen years I've been moving into a product for Rhizoctonia or whatever for the root rots and the crown rots and such, which is the Quadris. There might be a few other products out there like the ....seed treatment that I haven't been using, but nobody's really recommended it to me. I asked about it and they said, ah no don't use it.*

On the opposite side of the continuum from the *Epitome of Non-organic* is the *Epitome of Organic*.

Two farmers were grouped under the *Epitome of Organic* characterization (Table 4-2e). These farmers' management practices and perceptions of the farm system were characterized as feed the soil, mechanical pest management, skeptical of GM-crops, experience-based channels of communication, biological and soil organic matter soil quality indicators, and a complex systems approach. The following passage was taken from one of the farmers descriptions of how he manages pathogenic fungi on his farm. In this passage his description of mechanically managing fungal disease is grounded in his perception of the farm as a complex system.

> *The disease is part biology and part mechanical. I'll briefly take you down my process of selecting open pollinated corn...*
>
> *Among a whole bunch of other qualifiers, the ear has to be tipped downward at maturity. The husk has to cover the entire ear, none of it can protrude. Plus it also has to naturally loosen away from the ear. So it can do its job which is act as an umbrella and drying room for the grain inside. If the husk is too tight the moisture will stay in the ear and you can*

get mold. And that can be systemic or just be environmental from not having enough ventilation. Also the ear can't stick out because then you have insect and bird damage and that creates a vectoring point for disease which might not be systemic but just conditional, but it is still a problem in food crop.

Along the continuum, this group was placed under the ecological management strategy heading.

The group in between chemical and ecological management practices is comprised of a mixture of perspectives and interpretations found among the interview participants. The *Mixture* group contains six farmers with a diversity of agricultural management strategies including one grower who practices non-organic no-till on some fields; two growers who practice only non-organic no-till; the grower who has multiple systems; and two growers who are organically certified (Table 4-2c). All of these farmers contradict themselves in that their management practices do not fully align with their worldviews. This is exemplified in the following excerpts taken from a non-organic no-till farmer who actively questions many of the agrochemicals he uses, but continues to use them.

***Grower**: Sometimes I don't like spraying everything, but I think if you do it responsibly it's a big help and it's a good tool to use if it's used correctly.*

***Atwood**: Have you observed any changes in your soils that you would relate to the applications of glyphosate in your fields?*

***Grower**: Well sometimes we wonder about some of the algae that are growing on the soils, if it's killing them or not. I don't know if there's been much studies on that. As a no-tiller we do depend a lot on the micro-activities that's going on in the soils.*

All farmers in this group actively question chemically-based management tactics and are beginning to explore or think about ecological-based management tactics.

The final two groups in the characterization continuum, *Organic* and *Non-organic*, are situated next to the *Mixture* group. All farmers in *Organic* practice organic management strategies while all the growers in *Non-organic* use non-organic management strategies. The differences between the three interior groups are subtle. The following passages aid in distinguishing the *Organic* from the *Non-organic* group by demonstrating the differences in how the farmers assess and describe soil quality.

> ***Organic:*** *Feel and smell. Smell really if you can smell it and it smells, like when this was a chemical farm you'd work it the first time and it smelled good. And after that there was no smell to it at all. If you go out there right now and grab a handful even with it being wet it will smell and it will smell the whole summer and winter and everything. And you can see a healthy soil from the worm activity...And the way it reacts when you get a lot of water. If your soil is in good condition it handles the water well even in a drought.*

> ***Non-organic:*** *I guess the easiest thing would be looking at the top of [the soil] and observing whether it looks like a road, flat and sealed off and hard, compared to looking loose and you can see the grains of the dirt instead of just being smooth, and then of course if there's something growing, just how it's growing. Plant health, that's big. I guess that's really how I would look across the field.*

The organic farmer's description of soil quality centers on the use of biological and physical soil quality attributes whereas the non-organic farmer relies on physical attributes and crop health. The soil quality indicators the farmers use reinforces their fertility management strategies, either feed the soil or feed the crop. These farmers are either on the cusp of grasping a complex systems approach or are in the beginning stages of understanding this approach. This finding is central to this research because as farmers begin to view the farm as a set of processes and relationships as opposed to parts, the farmer is more apt to interpret the crops as an interdependent component of the farm system. The crop has a relationship with the soils and with the surrounding plants. The figure also shows that as a farmer moves towards a complex systems approach, he strives to farm in a more ecologically sound way that includes nourishing the processes between the soil and crops and the elimination of many agrochemical inputs because they interrupt the system's processes.

These results allow for interesting conclusions about how farmers' worldviews influence agricultural management practices. The focus of this research was initially on the potential impacts of glyphosate and fungicides on soil quality and crop health. The data show that non-organic farmers are experiencing higher rates of fungal disease in their crops than the organic farmers. By asking farmers directly to describe their observations, a story centered on differences in systems approaches to agricultural management evolved. In the end, the results demonstrate how complex and linear systems theory applies to organic and non-organic farmers. They show how farmers with a broad understanding of the farm system processes are more likely to seek advice from advisors with direct farming experiences and use more ecologically-based management practices. This finding provides useful insights into the field crop farming community that can be used as Michigan agriculture moves towards a sustainable system.

CHAPTER 5
CONCLUSIONS

The framework of ideas and values a farmer uses influences how he interprets and interacts with the farm system. This research represents one way of characterizing farmer worldviews with respect to management strategies, systems approaches, channels of communication and soil knowledge in an effort to understand the differences in organic and non-organic farmer's worldviews. Characterization of the farmers was necessary to further our understanding of non-organic and organic farmers' worldviews.

Results provide insight into the management practices, soil knowledge and preferred communication channels of the growers both individually and holistically (Figure 3-1). The major findings of this research include:

1. Both non-organic farmers and organic farmers perceive improvements or no change in the quality of their soils. Non-organic farmers identified improvements in chemical and physical soil quality attributes. Organic farmers say biological and physical soil quality attributes have improved.
2. Non-organic farmers observe a higher incidence of fungal disease than organic farmers in the Thumb region. Organic farmers relate the absence of disease to the healthy relationships within the farm system while non-organic farmers identified etiologic system components.
3. Organic farmers are well versed, compared to the non-organic farmers, in soil quality assessment. The soil quality attributes organic farmers use support the feed the soil philosophy: soil organic matter, biological and physical attributes. Whereas non-organic farmers mostly rely on soil quality attributes that support the feed the crop philosophy: crop health, chemical, and physical.
4. Non-organic farmers prefer expert-based channels of communication; whereas, organic farmers utilize experience-based channels. Each of these channels reinforces the farmers' perception of the farm as a system.

5. Organic farmers tend to perceive the farm as a complex system and non-organic farmers tend to view it as a linear system. The system's framework the farmer uses influences his use of chemically or ecologically-based management strategies.

The worldview characterization continuum (Figure 4-1) illustrates the gradient of worldviews that exist within a close-knit rural agricultural community. The diversity of worldviews gives rise to multiple management strategies and perceptions of the farm system. Within this diversity is farmer-driven innovation. Rather than polarizing farmers based on their management practices, fostering a shared appreciation among farmers with differing worldviews will provide new outlets for the exchange of ideas, methods, skills and innovations which can be used to improve all farms.

The dominant paradigm which accepts science in service to progress (Yankelovich, 1991), historically, has propelled agriculture in terms of mechanization, increased yields and the development of agrochemicals. These developments have aided farmers in streamlining the production of crops and reduced the time required to manage the farm system. This research, however, suggests a re-evaluation of this paradigm including the notion that humans have authority over nature. Non-organic farmers who use GM-crops, agrochemicals and perceived the farm as a linear system saw increased incidence of fungal disease. Future research should explore the cause of this finding, and farmers should use these results as a starting point for changing their management strategies to reduce disease rates. Educators and researchers should also utilize these findings as they construct new research projects and present findings to the agricultural community. Identifying the appropriate communication channels for the dissemination of this information will be among the first steps.

Ultimately, all farmers strive to be good stewards of the land. They all respect the bounty of the earth and want to see it maintained or improved in productivity. They will grasp the tools, skills and ideas that ensure they continue to have a viable farm. The appropriate information, however, must be available for them to do it.

Future Research

The research began with the purpose of determining if non-organic farmers and organic farmers were observing similar rates of fungal disease and changes in soil health. Disease surveys and soil quality studies should be conducted to determine if glyphosate is compounding the observed deleterious changes or if absence of diverse crop rotations and if the narrow row spacing are influencing the incidence of disease. It was evident during the interviews that the non-organic and organic farmers' responses were based on extremely different understandings of how farm systems operate. This observation led to a focus on differences in farmers' worldviews and perceptions of the farm as a system. The findings of the research should be used as a platform for future research. Identification of all the key differences between non-organic and organic worldviews will require refocusing the interview questions.

One way to further explore farmers' worldviews is by learning more about their educational backgrounds. Higher education can strongly influence worldviews (Schofer & Meyer, 2005). During the interviews there were strong indications that the organic farmers either pursued higher levels of education or had the opportunity to travel outside the Thumb region for extensive periods of time. Farmers, however, were not explicitly asked this question. This type of information would provide further insight into the farmer worldviews.

The research focused on two management systems: non-organic and organic. There are, however, a wide range of agricultural management strategies. The non-organic no-till farmers were relatively underrepresented with only two participants using this strategy. Their responses, particularly with respect to how they assess soil quality, hint at some fundamental differences in how these farmers understand and relate to the farm system, opposed to the other non-organic farmers. Determining what sets this type of farmer apart from other farmers will require a more extensive look at non-organic no-till farmers. Farmers practicing other management strategies, like low input and integrated pest management, should also be examined.

Romig *et al.* (1995), the Cornell Soil Health Program (2007) and this research are some of the first applications of soil knowledge concepts to farming communities in the United States. The majority of this research occurs in developing countries with indigenous and traditional communities. Developed countries deserve more attention with respect to soil knowledge research because their perceptions of a quality soil, like indigenous communities, influence their soil management strategies. The current research in the U.S. shows that farmers use crop appearance as one of their primary means of soil quality assessment. Research on the effects of a farmer's reliance on this indicator is important to developing future soil knowledge research for the U.S. It would also prove useful for future farmers, particularly those looking to broaden their understanding of farm systems.

Finally, expansion of the proposed grower worldview characterization continuum will require further qualitative research. Undoubtedly there are other criteria that differentiate farmers who use ecologically-based strategies from those who use chemically-based approaches. To ensure accurate characterizations, these criteria should emerge from the data. Many of the criteria will likely be subtle, but will provide useful insight into why farmers use or prefer one management practice over another.

APPENDICES

APPENDIX A

Non-Organic Farmer Interview Guide

1. Are you a full-time farmer? If no, please identify any off-farm sources of income.
2. Number of years farming?
3. How much land do you currently farm? Number of acres owned?
4. Which county(s) is your farm land located?
5. Who do you rely upon to learn about pests and pest management?
6. When you're in the field, what visual cues indicate a healthy soil from an unhealthy soil? (Organic matter, erosion, etc?) Please name as many indicators as you can for both a healthy soil and an unhealthy soil.
7. When you test your soil, what nutrients and ranges determine if your soils are healthy? What nutrients and ranges determine if your soils are unhealthy?

2009 Growing Season Seed Choice & Environmental Impacts

8. Which crops do you grow? What is your crop rotation?

The following questions refer to the 2009 growing season.

9. Please tell me the following information for each crop you grow.
   a. field size (acres)
   b. Seed varieties
   c. Inputs [fertilizers, herbicides, fungicides, insecticides, etc.]
      i. brand names
      ii. amount applied per acre
      iii. time of year inputs are applied
      iv. input application frequency
10. Prior to growing gm-crops what were you told these varieties would offer you?
    a. Why did you decide not to grow gm-crop varieties?
11. From your experiences, are gm-varieties living up to what you initially heard? Please be specific on the issues you've had with these varieties.
12. Over the years, has the amount of N, P, and K in the *fertilizer* you apply per acre increased, decreased or remained the same? Why do you think this is?
13. What year did you first start using *glyphosate?*
14. When you first used *glyphosate* how many times a season did you apply it?
15. Since you first began using *glyphosate*, has there been an increase, decrease or no change in the number of times you apply it per acre? Why?
16. Has the amount of active ingredient in the glyphosate products you apply per acre increased, decreased, or remained the same? (name the products)

17. Have you observed any changes in your soils that you would relate to the applications of *glyphosate* in the fields?
18. How did your father manage *weeds* on his farm?
19. Have you encountered any new (unusual) diseases on your farm? In which crop(s)? Please describe the plant's symptoms.
20. What year did you first start using *fungicides*?
21. Which fungicides have you tried in the past? (list)
22. How frequently do you apply fungicides (#years & # times per season)?
23. Has the frequency of fungicide applications increased, decreased or remained the same in the past 10 years? Why do you think this is?
24. How did your father manage *fungal problems* on his farm?
25. As a farmer, you have a firsthand year round glimpse at how the fertilizers, herbicides and fungicides interact with the soil and surrounding environment. Will you please describe for me any observations you have made regarding how these inputs, the *glyphosate (Round-Up)* and *pyraclostrobin (Headline)* specifically, are impacting the immediate environment including the quality of the soil?

Soil Quality Field Observations

26. Do you, or a hired agency/firm, regularly sample and test your soils?
    a. Which firm tests your soils?
    b. How often are your soils tested? Which tests are run?
    c. Do you test for heavy metals?
    d. What levels are manganese and iron at in your soil?
27. What changes in your soil composition and quality, if any, have you noticed over the years? What do you think is causing these changes to occur?
28. What are your main concerns regarding land stewardship and soil quality in the Thumb region?
29. If farmers in the Thumb region continue to farm as they currently do, do you think the soil quality in the region will improve, degrade, or remain the same in 10 years? Why?

APPENDIX B

Organic Farmer Interview Guide: Questions that differ from the non-organic interview guide are bolded.

1. Are you a full-time farmer? If no, please identify any off-farm sources of income.
2. How many years have you been farming?
3. How much land do you currently farm? How much of the land do you own?
4. Which county(s) is this land located?
5. **When did you begin growing your crops organically? Why did you decide to switch to organic production?**
6. Who do you rely upon to learn about pests and pest management?
7. When you're in the field, what visual cues indicate a healthy soil from an unhealthy soil? (Organic matter, erosion, etc?) Please name as many indicators as you can for both a healthy soil and an unhealthy soil.
8. When you test your soil, what nutrients and ranges determine if your soils are healthy? What nutrients and ranges determine if your soils are unhealthy?

2009 Growing Season Seed Choice & Environmental Impacts

9. Which crops do you grow? What is your crop rotation?

The following questions should be answered with information from the 2009 growing season.

10. Please tell me the following information for each crop you grow
    a. Field size (acres)
    b. Varieties
    c. Inputs [fertilizers, herbicides, fungicides, insecticides, etc.]
        i. Brand names
        ii. Amount applied per acre
    d. Time of year inputs are applied
    e. Cultivation schedule
    f. Input application frequency
11. How do you manage soil fertility?
    a. If the farmer uses an organic fertilizer ask...What type of fertilizer do you use? Have the quantities of N, P, & K in the *fertilizer* you apply per acre increased, decreased or remained the same? Why do you think this is?
12. **Do you think glyphosate resistant seed varieties benefit agriculture? Why or why not?**
13. **Have you ever used an herbicide product with *glyphosate?* Which product?**
14. **If so, when did you first use *glyphosate*? And how many times a season did you apply it? What did you use it for (e.g pre-plant burn down)?**
15. **Why did you stop using *glyphosate?***
16. **Since you began growing your crops organically, have you observed any changes in your soils that you would relate to the organic practices?**
17. How did your father manage *weeds* on his farm?

18. Have you encountered any new (unusual) diseases on your farm in the past 10 years? In which crop(s)? Please describe the plant's symptoms.
19. Have you experienced any fungal diseases? Which ones and in what crops?
20. How do you manage fungal problems in your fields?
21. Have you ever used an organic *fungicide*?
22. Which organic fungicides did you try & why? (list)
23. Has the frequency of fungal problems increased, decreased or remained the same in the past 10 years? Why do you think this is?
24. How did your father manage *fungal problems* on his farm?
25. **Will you please describe any observations you have made regarding how the quality of your soils differs from the conventional farm's soils you observed?**

Soil Quality Field Observations

26. Do you, or a hired agency/firm, regularly sample and test your soils?
    a. Which firm tests your soils?
    b. How often are your soils tested? Which tests are run?
    c. Do you know what levels are the Mn & Fe at in your soil?
27. What changes in your soil composition and quality, if any, have you noticed over the years? What do you think is causing these changes to occur? (if answered before skip questions)
28. What are your main concerns regarding land stewardship and soil quality in the Thumb region?
29. **If conventional farmers in the Thumb region continue to farm as they currently do, do you think the soil quality in the region will improve, degrade, or remain the same in 10 years? Why?**

Appendix C

Participant Consent Form

You are being asked to participate in a research project. Researchers are required to provide a consent form to inform you about the study, to convey that participation is voluntary, to explain risks and benefits of participation, and to empower you to make an informed decision. You should feel free to ask the researcher any questions you may have.

The researcher is studying field observations farmers in Huron, Sanilac, Lapeer and Tuscola Counties, Michigan have made with respect to environmental changes and crop inputs (e.g. fertilizers, herbicides, fungicides, and insecticides). You have been selected as a possible participant in this study because you are a farmer in either Huron, Sanilac, Lapeer or Tuscola County. Your name was obtained from previous soil quality research and by asking farmers in the region for potential interviewees. This research will be part of a larger case study centered on the public discussion and future of Michigan's Thumb region's soil quality and agricultural viability. The researcher is asking 10-25 farmers to participate in this study by being interviewed. Participants in the research must be at least 18 years old.

The potential benefits for participating in this study are that it documents your perspectives on the current and future challenges of farming in the Thumb; it can improve future agricultural research so that it fits the needs of modern farmers; and the results will inform you of how other local farmers responded to the interviews. It also provides an opportunity to understand better how farming in the Thumb is or is not successful and to consider directions the farming community might take in the future.

The potential risks for taking part in this study are that you might disclose proprietary information. You will not be asked for information that you consider to be confidential, and you are asked not to disclose confidential information. At worst, you would experience social and legal risks if you disclose confidential information. Social risks may include jeopardizing relationships with neighboring farmers and friends. However, this risk is minimal because the interviews focus mostly on your management practices, not friends'. Legal risks may include threats from seed and pesticide spray suppliers who believe the interviewee is harming the integrity of the company's products or potentially breaking a contractual agreement. This risk is also minimal because the interviews are not centered on determining which seeds and sprays impact the soils and the environment the most, but rather to raise critical questions you, as a farmer, have regarding modern agricultural practices. You should feel free to ask the researchers any question you may have at any time.

Your name and your farm's name will be changed to fictitious names in the final report. The researchers will keep a code sheet in locked file cabinets in their offices and on password-protected computers. Other details about you and your business such as land owned and crops grown will not be changed in the final report. Your confidentiality will be protected to the maximum extent allowable by law.

The interview portion of the study will take 60 to 90 minutes of your time. It will be recorded if you grant permission (below). The interview audiotapes as well as transcriptions will be kept confidential. They will be stored on a password-protected computer in the researcher's office for at least three years after the project is complete (January 15, 2013) and not more than four years after the project is complete (January 15, 2014). Paper copies of the transcripts will be stored in locked file cabinets in the researcher's office for at least three years and not more than four years after the project is complete. Computer files will then be deleted and paper copies will be shredded. Only the researcher and the Institutional Review Board will have access to the interview recordings and transcripts.

Please indicate whether you agree to be audiotaped during the interview.

- I agree to allow audiotaping of the interview.
  ☐ YES ☐NO Initials ____________

The results of this study may be published or presented at professional meetings. The researchers will send you an electronic copy of all published papers if you provide your email address.

- I would like to receive an electronic copy of all published papers.
  ☐ YES ☐NO Email Address ________________________

Participation in this research project is completely voluntary. You have the right to say no. You may change your mind at any time and withdraw; simply notify the researchers that you no longer wish to participate. You may choose not to answer specific questions. You will be told of any significant findings that develop during the course of the study that may influence your willingness to continue to participate in the research. You will not receive money or any other form of compensation for participating in this study.

If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researchers:

- Lesley Atwood, MS student, Department of Community, Agriculture, Recreation and Resource Studies, Michigan State University, 131 Natural Resources Bldg., East Lansing, MI 48824, 850.512.4447, atwoodle@msu.edu
- Dr. Jim Bingen, Professor, Department of Community, Agriculture, Recreation and Resource Studies, Michigan State University, 131 Natural Resources Bldg., East Lansing, MI 48824, 517.353.1905 bingen@msu.edu

If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about his study, you may contact, anonymously if you wish, the Michigan State University's Human research Protection Program at 517.355.2180, Fax 517.432.4503, or email irb@msu.edu or regular mail at 207 Olds Hall, MSU, East Lansing, MI 48824.

Your signature below means that you voluntarily agree to participate in this research study.

Signature & Date

You will be given a copy of this form for your files.

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