THE COOPERATIVE PROVISION OF

ECOSYSTEM SERVICES IN AGRICULTURE

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by

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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

THE COOPERATIVE PROVISION OF

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Professor Harvey James

Professor Laura McCann

Professor Raymond Massey

Professor Anna Ball

. . . . . Thanks, Mom, for showing me that family and school can mix

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ABSTRACT

Managing agricultural lands to provide ecosystem services (ES) may be essential for the long-term sustainability of agriculture. Most agricultural lands, however, are managed for the short-term production of food, fiber, and fuel, often at the expense of other ES. Cooperative solutions where stakeholders work together to provide ES may increase the provision of ES in agriculture. However, little is known about the cooperative provision of agricultural-related ES. This dissertation fills this research gap by answering three basic questions about cooperative ES provision: 1) Which agricultural-related ES are suited for collective management? 2) Are farmers willing to cooperate to provide the ES, pest control, and if so, what types of cooperation are they willing to consider and what determinants affect that willingness? and 3) What role do different types of trust play in farmers' willingness to cooperate to control pests? We find that natural pest control, pollinating services and water quality are the ES most suited to collective management. We find most Missouri farmers are willing to cooperate to control pests, and simple, local cooperative efforts may be more popular than more formal, regional efforts. In addition, the perceived benefit of cooperation, environmental concern, social capital, extension agent contact and farmer preference for group work, are much more important than trust in determining farmers' willingness to cooperate. This

dissertation is important because it may facilitate moving cooperate ES provision in agriculture from scholarly speculation to actual practice.

CHAPTER ONE

The Provision of Ecosystem Services in Agriculture[1]

1. Introduction

Agricultural ecosystems provide many ecosystem services (ES) which are essential to human health and well-being, including production services such as food and fiber; regulating services such as soil retention and pest control; supportive services such as nutrient cycling and water filtration; and cultural services such as nature recreation and rural lifestyles (Table 1). In turn, some ES affect agricultural productivity, including soil fertility and pollination services (Dale and Polasky, 2007). Managing agricultural lands to provide more ES and higher quality ES may be essential for the long-term sustainability of agricultural ecosystems (Antle and Capalbo, 2001; Swinton et al., 2007). Most agricultural lands, however, are managed for the short-term production of food, fiber, and fuel, often at the expense of other ES (Swinton et al., 2007).

[1] published in a slightly different form in *The Encyclopedia of Food and Agricultural Ethics*, 2014

Table 1.1. Selected Ecosystem Services (ES) and Disservices (ED) from Agriculture

ES Type	ES from Agriculture	ES used as Inputs	ED from Agriculture
Regulating Services	Soil retention	Soil retention	Soil erosion
	Pollination	Pollination	Competition for pollination
	Pest control	Pest Control	Pest outbreaks
	Water purification		Nutrient run-off Pesticide run-off
	Habitat provision		Habitat loss
	Atmospheric Regulation		Greenhouse gas emissions
	Flood control		Flooding
	Seed dispersal		Loss of Seed Dispersal
Supporting Services	Soil structure	Soil structure	Soil compaction
	Soil fertility	Soil fertility	Soil fertility loss
	Biodiversity	Genetic biodiversity	Biodiversity loss
	Water cycling	Soil moisture	Soil moisture loss Competition for water from other ecosystems
	Nutrient cycling	Soil nutrients	Eutrophication of rivers, estuaries, and lakes
Cultural Services	Aesthetic landscape		Loss of aesthetic value
	Recreation		Loss of recreation value
	Spiritual well-being		Loss of well-being
	Rural lifestyles		Loss of rural culture and lifestyles
Production Services	Food Fuel Fiber		

Sources: Zhang et al., 2007; Tillman et. al., 2002; Swinton et. al., 2007; Dale and Polasky, 2007; Barrios, 2007; Millennium Ecosystem Assessment, 2005

Proposed solutions to the underprovision of ES often involve government regulation or market incentives (Kroeger and Casey, 2007; Brauer et. al., 2006; and Swinton et al., 2007). A growing number of scholars, however, recognize the potential for a third approach—cooperative solutions where stakeholders work together to provide

ES (e.g. Goldman et. al., 2007). Like market and government solutions, cooperative solutions involve costs and benefits that must be carefully examined to determine the most efficient, politically feasible, and socially feasible way to achieve a desired level of ES provision. One important step in this process is to determine which agricultural-based ES may be candidates for provision through cooperative solutions and which may not. Research is also needed to assess farmers' willingness to participate in cooperative solutions and the determinants that may affect that willingness.

The objectives of this dissertation are to answer three basic questions about the collective provision of ES in agricultural ecosystems: 1) Which ES are suited for collective management and which are not? 2) Are farmers willing to participate in the collective management of an ES, such as pest control, and if so, what are some of the determinants that affect that willingness? 3) What role does trust play in farmers' willingness to cooperate to control pests?

In this first chapter, I define terms, introduce the general problem of the underprovision of ES in agriculture, discuss proposed solutions to the problem of underprovision, and introduce collective provision as a viable solution. In chapters 2-4, I present three essays on the collective provision of ecosystem services in agricultural ecosystems. Each essay is designed to answer one of the three basic questions posed above and is written for publication in a peer-reviewed journal. Chapter 1 was published in a slightly different form in the *Encyclopedia of Food and Agricultural Ethics* in 2014. Chapter 2 was published in *Ecological Economics* in 2011. Chapter 3 is under review for *Ecological Economics* and Chapter 4 has not been submitted to a journal. Finally, chapter 5 includes a summary of important results and concluding remarks.

2. Ecosystem Service Provision

An ecosystem is a community of living organisms, including plants, animals and microbes, plus the non-living components of their environment, such as water and minerals, interacting together as a system or an ecological unit (e.g. a pasture or a forest). As the components of an ecosystem interact, they form a type of natural capital that provides flows of vital goods and services to humans (Daily, 1997). These goods and services are called ecosystem services (ES) and are often defined as the "benefits people obtain either directly or indirectly from ecosystems (MEA, 2005)." Many ES are critical to human survival (e.g. climate regulation and nutrient cycling), while others contribute to our well-being (e.g. nature recreation and rural lifestyles) (Kremen, 2005).

Scientists and scholars have traditionally focused on natural ecosystems, such as wetlands and ponds, for ES provision (e.g. Daily, 1997). However, other scholars are beginning to recognize the crucial role agriculture plays in ensuring humans receive an adequate flow of ES to sustain our quality of life (e.g. Swinton et al., 2007). Agriculture may be important for two main reasons. First, almost half of all global land that is not desert, tundra, rock, or boreal, is in agricultural production, making farmers the chief managers of the most productive lands on Earth (Tillman et al., 2002). Second, how farmers manage their land greatly impacts human health and well-being, the land's future productivity, neighboring ecosystems such as wetlands and forest, and the sustainability of the world food supply (Foley et al., 2005; Horrigan et al., 2002).

Despite agriculture's importance to ES provision, most farmers face strong incentives to manage their land for the short-term production of food, fiber, or fuel. The long-term health of agricultural ecosystems, however, as well as their ability to sustain food production and to provide society with diverse benefits, requires that farmers expand their management focus to include the provision of ES (Goldman et. al., 2007; MEA, 2005). In fact, some scholars argue that one of the greatest needs in agriculture, if not the greatest, is the provision of non-production related ES such as water purification and climate regulation (e.g. Antle and Capalbo, 2001).

3. Ecosystem Services in Agriculture

Although the provision of ES in agriculture sounds complex, it can be viewed simply as the efforts of agricultural producers to enhance the viability and stability of agricultural ecosystems by choosing management practices that jointly produce non-production related ES alongside livestock and crops.

Dale and Polasky (2007) identified three critical ways in which agriculture interacts with ES. First, agricultural ecosystems provide many vital ES. As shown in Table 1.1, these include production services such as food, fiber and fuel; regulating services such as soil retention, carbon sequestration and pest control; supportive services such as nutrient cycling, soil fertility and water filtration; and cultural services such as spiritual well-being, nature recreation and rural lifestyles. Although agricultural ecosystems have traditionally been managed to primarily provide production services, they may also be managed to provide other ES jointly with food, fuels and fiber (Wossink and Swinton, 2007; Dale and Polasky, 2007). In fact, the type, quality and quantity of ES that agriculture can provide is directly affected by the management decisions of farmers, both individually and collectively (Dale and Polasky, 2007).

Second, agriculture requires many ES as inputs to production, especially soil fertility, pollination, genetic biodiversity, nutrient cycling and pest control (Zhang et al., 2007; Power, 2011). Some of these ES are provided by the agricultural ecosystem itself, while others are provided by nearby natural ecosystems that exist within the greater agricultural landscape, such as woodlots, wetlands, and ponds (Zhang et al., 2007). Whether any particular agricultural ecosystem provides these input-related ES depends on the management decisions of numerous landowners, including the farmers who use the ES for production and neighboring farmers and land-owners (Goldman, 2007; Dale and Polasky, 2007; Power, 2011).

Third, agriculture affects the quality and quantity of ES which other ecosystems, such as forests or estuaries, can provide (Dale and Polasky, 2007). If these effects on other ecosystems are negative, they are called "disservices" of agriculture and often lay on the opposite end of a continuum from some important ES. For example, if a farmer practices conservation tillage, his land may provide the vital ES of soil retention. If a farmer uses conventional tillage practices on sloped fields, however, his land may provide the opposing disservice of soil erosion, plus the resulting environmental degradation caused by stream sedimentation, loss of soil fertility, and the chemical contamination of water. These disservices in turn affect the quantity and quality of ES that the stream or down-stream lakes and estuaries can provide (Dale and Polasky, 2007; Zhang et al., 2007). A lake that is contaminated with phosphorus, nitrogen, pesticides and sediments provides fewer ES and lower quality ES, such as wildlife habitat, biodiversity and nature recreation, than a lake that has not been contaminated (Zhang et al., 2007).

As a result of these three ways in which agriculture interacts with ES—the ability to provide ES, the requirement of ES as inputs, and the ability to affect neighboring ecosystems' provision of ES—managing agricultural lands to provide more and higher quality ES has the potential to greatly increase the sustainability of agricultural ecosystems, to increase the sustainability of neighboring ecosystems, and to decrease the environmental damage which may accompany intensive agriculture (Horrigan et al., 2002; Tillman et al., 2002; Foley et al., 2005; MEA, 2005). Most scholars agree, however, that increasing the provision of ES in agricultural ecosystems will not be easy (e.g. Goldman et al., 2007) and will likely require society to change the incentive structure that farmers currently face (e.g. Swinton et al., 2007).

4. Incentive Structures in Agricultural Ecosystems

The importance of understanding incentives in the provision of ES can be illustrated in two ways. First, some traditional agricultural products and ES, such as corn and pest control, can be complementary products, creating a win-win situation for agricultural producers. For example, setting aside a small area of land as habitat for crop pollinators provide a vital ES, which in turn might increase the value of crop production by more than the opportunity cost of the income forgone from not planting the habitat area in crops (Wossink and Swinton, 2007). Conversely, many traditional agricultural products and ES are competitive products, creating a win-lose scenario in which the farmer has little incentive to provide the ES (Wossink and Swinton, 2007). These competitive ES include flood control, carbon sequestration and water purification—vital ES that our society highly values, yet which are underprovided (Lant et al., 2008).

Second, agricultural activities that result in harm to the environment (e.g. intensive livestock or crop production that results in animal wastes or chemical fertilizers seeping into aquatic ecosystems) could become positive ES with the right incentives. Often what is needed is a change in just a few management practices. For example, the siltation of streams resulting from tillage agriculture can become the ES of soil retention with the adoption of conservation or no-tillage practices, grassed waterways, or permanent vegetative buffer zones beside streams and lakes.

Although joint production of traditional agricultural products, such as corn, and non-production related ES, such as wildlife habitat, is both possible and desirable for society (Wossink and Swinton, 2007; Robertson and Swinton, 2005), most farmers face strong incentives to manage their land for the short-term production of food, fiber or fuel, often at the expense of other vital ES (Tillman et. al., 2002; Swinton et al., 2007). For example, most farmers manage their land for the provision of production-related ES, such as wheat, because these services are private goods; the farmer enjoys most of the benefits of production (e.g. income from the crop) but does not pay all of the costs (e.g. loss of income in a downstream community due to eutrophication of fisheries from excess nitrogen in the water). Likewise, farmers disfavor the provision of cultural, supportive, or regulating ES, such as water purification, because the farmers pay all (or most) of the costs of provision (e.g. leaving land out of production next to a stream) but only enjoy a portion of the benefits (e.g. better bird watching on the farm). In some cases, farmers pay all of the costs of provision but receive no benefits, either because their efforts have no discernible effect on the ES (e.g. one farmer's effort to improve water quality in a large lake) or because the ES is appropriated by other users (e.g. flood control for downstream communities).

Incentive structures where the provider pays all or most of the provision costs but only receives a portion of the benefits are associated with public or quasi-public goods, which are how most scholars classify ES (e.g. Swinton et al., 2007). This incentive structure leads to an underprovision of ES because of the free-riding problem; people have little incentive to pay the cost of providing a public good when someone else might pay the cost of provision and the non-payer or free-rider can still enjoy all of the benefits of the good (Olson, 1965).

Solutions to the free-rider problem usually involve government provision or a restructuring of incentives to encourage private provision. How to best restructure these incentives, however, is a problem that scientists, scholars and other stakeholders have yet to solve. Many scholars believe that the traditional government and market solutions for the provision of public goods will provide the most effective way to increase ES provision in agriculture (e.g. Kroeger and Casey, 2007). A growing number of scholars, however, recognize the potential of a third major approach—cooperative solutions where landowners work together to provide ES (e.g. Sarker et al., 2008). In the following sections, I discuss these three major approaches to ES provision and make a case for cooperative solutions.

5. Market and Government Solutions to the Underprovision of ES in Agriculture

In the case of agricultural-related ES, government and market solutions are designed to reduce the free-rider problem by changing the incentive structure that farmers face. This may mean 1) increasing the cost of not providing an ES (e.g. assessing a fine if a farmer fails to create a buffer zone along a stream corridor) or 2) increasing the benefit of ES provision (e.g. creating a mechanism for farmers to receive price premiums on products that are produced in conjunction with ES). These solutions to ES provision may include legal approaches, such as liability laws and property rights; policy approaches, such as taxes and subsidies; educational approaches, such as extension services and public education classes; induced market approaches, such as cap and trade and regulation-driven markets; and free-market approaches, such as eco-labeling, food tracking systems, and marketing cooperatives dedicated to sustainable agriculture (Kroeger and Casey, 2007; Bräuer et al., 2006; Swinton et al., 2007).

Although these government and market solutions have the potential to increase ES provision in agriculture, many controversies and barriers to their implementation exist. For example, many government and market solutions may be costly to implement, monitor or run (e.g. Power, 2010; Kroeger and Casey, 2007). Measuring and monitoring of ES may be especially problematic because many ES are so interrelated that it is hard to distinguish one from the other or to define them, so double-counting becomes a risk (Dale and Polasky, 2007; Swinton et al. 2007). Plus, we do not currently have the technical ability to measure some ES accurately enough to monitor provision, or conversely to monitor the opposing disservice, such as non-point source pollution in streams (Swinton et al. 2007). Other barriers to market and government solutions discussed in Power (2010), Kroeger and Casey (2007) and Swinton et al. (2007) include 1) the cost of creating and running new markets, such as a carbon exchange market, 2) the cost of creating and running a certification systems, such certified organic products,

3) the costs of regulating the opposing disservice if ES are not provided, such as regulating non-point source pollution in streams, 4) start-up costs for farmers, such as the equipment, education and input costs associated with switching from conventional tillage to a no-tillage system (Gedikoglu and McCann, 2010), 5) information costs, such as technical knowledge of the management practices that will provide ES or the knowledge of why ES may be important to agricultural sustainability (Gedikoglu and McCann, 2010), 6) lack of trust in the governmental agency responsible for the payment of ES program or for the dissemination of information about that program, such as a state conservation agency (Raedeke et al., 2001) and 7) social and psychological costs, such as fear of the unknown or the social risk of being different (Carolan, 2005; Koundouri et al., 2006).

Consider a farmer who wants to practice integrated pest management (IPM) as part of a program to improve water quality in a stream used for municipal drinking water in a down-stream rural community. IPM is a pest management system that requires monitoring pest populations and taking actions, such as pesticide application or cultural control, only when a certain threshold is reached (Flint, 2012; Dent, 1995). To effectively practice IPM, the farmer must know how to monitor soil, crops and pest populations in his or her fields in order to target the timing, placement, and amount of fertilizer or pesticide needed to achieve the greatest benefit for the crop without using excess chemicals (Flint, 1981). This skill set requires knowledge and experience that many farmers and extension personnel lack or cannot find access to, despite increasing demand for the knowledge (e.g. Carolan, 2006, Rodriguez et al., 2009, and Hayes, 2001). In fact, Carolan (2005) found that almost three quarters of extension personnel and agricultural professionals in Iowa lacked the technical knowledge to assist a farmer in implementing sustainable agricultural practices such as IPM.

In addition to the substantial skill set needed to practice IPM, many IPM practices are proven effective when used as part of a larger sustainable management system, but may not be cost or time efficient when used alone (Carolan, 2006). For example, farmers practicing basic IPM techniques, such as monitoring crops for pests, may also benefit from knowing how to enhance pest control through cultivation techniques, crop rotations, disease or pest-resistant cultivars, the use of cover crops, or a complete redesign of the farmers' operation to enhance the ecological processes that would make the use of pesticides or herbicides unnecessary. Again, information costs for these complementary practices are high, as are the start-up costs for the farmer, especially for those who are redesigning their operation, not just making minor changes to conventional practices (Macrae et al., 1993).

Farmers who practice IPM may also face social costs in the form of criticism or trust issues with neighbors or landowners who hold traditional beliefs that "weedy" fields and "un-kept" hedgerows reflect poorly on the farmer's character (Carolan, 2005; Carolan, 2006). Finally, the full benefits of IPM may be hard to monitor. For example, IPM not only may provide the ES, water quality, is may also provide or enhance other vital ES, such as soil fertility, soil structure, soil retention, nature recreation, water cycling, natural pest control, and pollination services, some of which are so interrelated it would be hard to monitor them separately (Barrios, 2007; Dale and Polasky, 2007; Swinton et al., 2007). How the farmer or a government agency responsible for payments for ES will recognize and monitor changes in ES provision is uncertain.

Although farmers and government officials face many implementation barriers to government and market solutions, many scholars believe these solutions may help encourage the provision of agricultural-related ES (e.g. Kroeger and Casey, 2007). Some scholars, however, question if these traditional approaches to the free-rider problem are enough (e.g. Goldman et al., 2007). The goal of most government and market solutions is to entice enough farmers to manage their land for the provision of nonproduction-related ES so that a socially-desired quantity of ES is achieved. One potential problem with these approaches, however, is that they often ignore the fact that many ES require landscape level management to provide optimal benefits (Goldman et al., 2007). In other words, individual incentive approaches ignore the potentially large and important incentive of a collective benefit which only may be achieved if most farmers in the region cooperate in their effort to provide ES (e.g. Sarker et al. 2008). It is in this context that cooperative solutions become important.

6. Cooperative Solutions to the Provision of ES in Agriculture

Ostrom (1990) argues that collective management is a viable, yet commonly-overlooked, third solution to the underprovision of a natural resource such as ES. Collective management often involves a group of citizens who jointly manage a community-owned property, such as a group of herdsmen who manage a common pasture. It may also involve a group of citizens who jointly manage individually-owned properties, such as members of a neighborhood association who jointly make and follow rules regarding noise levels in order to better enjoy their neighborhood.

When people work together they often achieve a collective benefit that could not be achieved by the group members' individual efforts. In the collective management of a natural resource, most participants hope to achieve the collective benefit of a stable resource base, although other collective benefits may be achieved. For example, an inshore fishery in Alanya, Turkey was threatened by hostilities, harvest uncertainty, and lost productivity because fishers were fighting over the most productive fishing spots (Berkes, 1986). In response, members of the local fishing cooperative devised a set of rules which assigned fishing spots on a daily basis, giving each fisher an equal chance to fish highly productive spots and less productive spots. This collective management regime, enforced by the fishers themselves, created a more productive fishery since better spacing of the fishers optimized production at each site. In addition, fishers no longer wasted resources searching for or fighting over sites, plus they achieved more harmonious relationships within their community. Each of these benefits represents a collective benefit that could not have been achieved by the fisher's individual efforts. These collective benefits were only achieved because the fishers worked together to devise and enforce a set of rules for managing the local fishery (Ostrom, 1990).

In the collective management of an ES, participants may hope to achieve the collective benefit of enhanced ES provision, environmental damage mitigation or the prevention of future regulations (Lubell, 2004). For example, Ayer (1997) describes cotton farmers in Arizona who collectively managed for pest control by practicing collective integrated pest management. After devising and enforcing a set of collective IPM rules, these farmers achieved fewer pest outbreaks, drastically reduced input costs and reduced confrontations with neighboring communities regarding water and air quality issues—benefits that were only achieved when most of the cotton farmers in a region worked together to enhance the ES of pest control (Ayer, 1997).

Not only may collective management be a viable solution for the provision of ES in agriculture, proponents of cooperative approaches often point to the spatial scale-mismatch between ES and agriculture as justification for its necessity (e.g. Goldman et al., 2007). This mismatch occurs because the spatial scale of management in agricultural ecosystems (e.g. a 500 acre farm) often does not match the spatial scale of ecosystem processes necessary to provide ES (e.g. a tri-county watershed), making cooperation necessary (Cumming et al., 2006; Pelosi et al., 2010). Consider our earlier discussion of the three ways in which agriculture interacts with ES—the ability to provide ES, the requirement of ES as inputs, and the ability to affect neighboring ecosystems' provision of ES. In the discussion of these three ways, we learned that ES provision depended not only on individual farmers' management decisions, but also on neighboring farmers and landowners decisions and on the neighboring ecosystems. For example, pest insect and pathogen movements involve landscape-level processes, as does the ES, natural pest control, and the ecological processes that can keep pest pathogens and insects in check (Tscharntke et al., 2007). These processes include the species pool in the surrounding landscape, the structural complexity of the landscape, the connectivity of breeding and rest habitats, and the distance of the crop from natural habitat—each very important for the conservation of pest enemy diversity and the maintenance of pest enemy populations large enough to effectively control pests (Bianchi et al., 2006; Tscharntke et al., 2007).

Although some ES may be well-suited to collective provision, collective solutions also face many barriers to implementation (e.g. Ostrom, 1990, 2001). In addition to many of the same barriers that farmers face with government and market solutions—such as start-up costs, information costs, lack of trust in the sponsoring agency and social costs—farmers who work together to provide ES also face barriers such as lack of trust in other farmers or stake-holders, lack of information about other farmers' past actions, lack of a common vision, or organizing costs, especially with large groups (Olson, 1965; Ostrom, 1990, 2001, 2009; Pretty, 2003).

Consider our earlier example of an individual farmer who wanted to begin practicing IPM after joining a government program to help provide higher water quality to down-stream rural water municipalities. Now consider twenty farmers who must work together to accomplish the same goal. Water quality is highly dependent on landscape level processes (e.g. Sarker et al., 2008). In fact, encouraging farmers and other stake-holders to work together may be the only way water quality can be significantly improved. However, farmers working together must agree on a common vision for their work. They must come up with a set of rules and guidelines to follow, and they must trust that other participants in the group will follow through on their commitments (Ostrom, 1990, 2001). Additionally, the farmers face the same start-up costs, information costs etc. that they would face individually if they wished to provide ES, although it may be possible for farmers to collectively gather and share information or to pool resources to cover start-up costs.

7. Conclusion and Goals of the Dissertation

Agriculture can have a profound effect on the environment, for good or for ill. Thus, farmers are in a unique position to provide ecosystem services that are important to agriculture and society through the farm management practices they adopt. However, farmers face short-term incentives to focus on production-related services, often at the expense of providing the longer-term benefits of ES. For this reason, the underprovision of ES can be defined, as Lant et al. (2008) did, as the “Tragedy of Ecosystem Services,” in honor of Hardin’s (1968) analysis of the “Tragedy of the Commons.” The tragedy results from the overconsumption of common pool resources in agricultural ecosystems, such as pasture lands, and from the underprovision of public goods, such as carbon sequestration or natural pest control. Thus, one of the most important issues that surrounds the provision of ES in agriculture is similar to the problem of providing any public good or managing any common pool resource—which is how to identify and encourage the provision of ES by those most capable of doing so.

A promising answer to this dilemma may include encouraging farmers to work together to provide ES in agricultural ecosystems. However, little is known about which ES may be best provided by cooperative management, whether farmers are willing to cooperate to provide ES, what types of cooperation they may be willing to consider, and what determinants may affect farmers' willingness to cooperate. The three essays in this dissertation will help fill these gaps in the literature.

Essay 1 explores which agricultural-related ES are suited for collective management and which are not. Essay 2 builds on Essay 1 by exploring whether or not Midwestern farmers are willing to cooperate to provide pest control, one of the ES that is most suited to collective management. Plus, Essay 2 examines what types of cooperative pest control activities farmers are willing to consider and what determinants may affect that willingness. Finally, Essay 3 builds on Essay 2 by further exploring the role trust plays in farmers' willingness to cooperate to control pests. A survey instrument was used to answer the research questions in Essays 2 and 3. See appendix A at the end of this dissertation to review this instrument.

8. References

Antle, J. M, and S. M Capalbo. 2002. Agriculture as a managed ecosystem: policy implications. *Journal of Agricultural and Resource Economics* 27(1):1-5.

Ayer, H. W. 1997. Grass roots collective action: agricultural opportunities. *Journal of Agricultural and Resource Economics* 22:1–11.

Barrios, E. 2007. Soil biota, ecosystem services and land productivity. *Ecological Economics* 64:269-285.

Berkes, F. 1986. Local level management and the commons problem: A comparative study of Turkish coastal fisheries. *Marine Policy* 10:215-229.

Bräuer, I., R. Mϋssner, K. Marsden, F. Oosterhuis, M. Rayment, C. Miller, and A. Dodoková. 2006. The use of market incentives to preserve biodiversity. *ECOLOGIC, 51p.*

Carolan, M. S. 2005. Barriers to the adoption of sustainable agriculture on rented land: An examination of contesting social fields. *Rural sociology* 70:387–413.

Carolan, M. S. 2006. Do you see what I see? Examining the epistemic barriers to sustainable agriculture. *Rural sociology* 71:232–260.

Cumming, G.,D. Cumming and C. Redman. 2006. Scale mismatches in social-ecological systems: causes, consequences, and solutions. *Ecology and Society 11*(1):1-14.

Daily, G.C. (Ed.), 1997. *Nature's Services: Societal Dependence on Natural Ecosystems.* Island Press, Washington, DC. 392 pp.

Dale, V. H., and S. Polasky. 2007. Measures of the effects of agricultural practices on ecosystem services. *Ecological Economics* 64:286-296.

Dent, D. (Ed.) 1995. *Integrated Pest Management*. Springer. 356pp.

Flint, M. L. 2012. *IPM in practice: principles and methods of integrated pest management*. Vol. 3418 UCANR Publications. 131 pp.

Flint, M. L. and R. Van den Bosch. 1981. *Introduction to Integrated Pest Management*. New York: Plenum Press.

Foley, J. A., R. DeFries, G. P. Asner, C. Barford, G. Bonan, S. R. Carpenter, F. S. Chapin, M. T. Coe, G. C. Daily, H. K. Gibbs, J. H. Helkowski, T. Holloway, E.A. Howard, C. J. Kucharik, C. Monfreda, J. A. Patz, C. Prentice, N. Ramankutty, and P. K. Snyder. 2005. Global Consequences of land use. *Science* 309:570-574.

Gedikoglu, H. and L. M. J. McCann. 2010. What causes farmers to adopt agricultural and conservation technologies and how can we use that knowledge to improve policies, programs and technologies. In: *Human Dimensions of Soil and Water Conservation: A Global Perspective.* Editor: T. L. Napier. Nova Science Publishers Inc.

Goldman, R. L., B. H. Thompson and G.C. Daily. 2007. Institutional incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. *Ecological Economics* 64:333-343.

Hardin, G. 1968. The Tragedy of the Commons. *Science* 162:1243-1248.

Hayes, S. 2001. Breaking down the barriers: The Schoharie county local agri-preneurship project for next generation farmers. *Journal of Sustainable Agriculture* 19:85-108.

Horrigan, L., R. S Lawrence, and P. Walker. 2002. How Sustainable Agriculture Can Address the Environmental and Human Health Harms of Industrial Agriculture. *Environmental Health Perspectives* 110:445.

Koundouri, P., C. Nauges, and V. Tzouvelekas. 2006. Technology Adoption under Production Uncertainty: Theory and Application to Irrigation Technology. American Journal of Agricultural Economics 88:657-670.

Kremen, C. 2005. Managing ecosystem services: what do we need to know about their ecology? *Ecology Letters* 8:468–479.

Kroeger, T. and F. Casey. 2007. An assessment of market-based approaches to providing ecosystem services on agricultural lands. *Ecological Economics* 64:321-332.

Lant, C. L, J. B. Ruhl, and S. E Kraft. 2008. The tragedy of ecosystem services. *BioScience* 58:969–974.

Lubell, M. 2004. Collaborative watershed management: A view from the grassroots. *Policy Studies Journal* 32(3):341-361.

Macrae, R. J, J. Henning, and S. B Hill. 1993. Strategies to overcome barriers to the development of sustainable agriculture in Canada: the role of agribusiness. *Journal of Agricultural and Environmental Ethics* 6:21–51.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-Being: Current State and Trends, vol. 1.* IslandPress, Washington, DC.

Olson, M. 1965. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, Mass.: Harvard University Press.

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.

Ostrom, E. 2001. Reformulating the Commons. In *Protecting the Commons: A Framework for Resource Management in the Americas*, ed. Joanna Burger, Elinor Ostrom, Richard B. Norgaard, David Policansky,and Bernard D. Goldstein. Washington, DC: Island Press, 17–41.

Ostrom, E. 2009. Analyzing Collective Action. Keynote papers presented in the Plenary Sessions of the 27th Conference of the International Association of Agricultural Economists. 16-22 August 2009, Beijing, China.

Pelosi, C., M. Goulard and G. Balent. 2010. The spatial scale mismatch between ecological processes and agricultural management: Do difficulties come from underlying theoretical frameworks? *Agriculture, Ecosystems & Environment* 139(4):455-462.

Power, A. G. 2010. Ecosystem Services and Agriculture: Tradeoffs and Synergies. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365, no. 1554 : 2959–2971.

Pretty, J. 2003. *Social Capital and the collective management of resources.* Science 302:1912-1914.

Raedeke, A. H, C. H Nilon, and J. S Rikoon. 2001. Factors affecting landowner participation in ecosystem management: a case study in south-central Missouri. *Wildlife Society Bulletin* 29(1):195–206.

Robertson, G. P., and S. M. Swinton. 2005. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. *Frontiers in Ecology and the Environment* 3:38–46.

Rodriguez, J.M., J.J. Molnar, R.A. Fazio, E. Sydnor, and M.J. Lowe. 2009. Barriers to adoption of sustainable agriculture practices: Change agent perspectives. *Renewable Agriculture and Food Systems* 24:60-71.

Sarker, A., H. Ross,and K.K. Shrestha. 2008. A common-pool resource approach for water quality management: An Australian case study. *Ecological Economics* 68:461-471.

Swinton, S. M., F. Lupi, G. P. Robertson and S. K. Hamilton. 2007. Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits. *Ecological Economics* 64:245-252.

Tillman, D., K.G. Cassman, P.A. Matson, R. Naylor and S. Polasky. 2002. Agricultural sustainability and intensive production practices. *Nature* 418:671–677.

Wossink, A. and S. M. Swinton. 2007. Jointness in production and farmers' willingness to supply non-marketed ecosystem services. *Ecological Economics* 64:297-304.

Zhang, W., T. H. Ricketts, C. Kremen, K. Carney, and S. M Swinton. 2007. Ecosystem services and Dis-services to agriculture. *Ecological Economics* 64:253–260.

CHAPTER TWO

Ecosystem Services in Agriculture:

Determining Suitability for Provision by Collective Management[2]

Abstract: Agricultural ecosystems provide many ecosystem services (ES) which are essential to human health and well-being. In turn, some ES affect agricultural productivity. Managing agricultural lands to provide more ES and higher quality ES may be essential for the long-term sustainability of agricultural ecosystems. Most agricultural lands, however, are managed for the short-term production of food, fiber, and fuel, often at the expense of other ES. Proposed solutions to the underprovision of ES often involve government regulation or market incentives. A growing number of scholars, however, recognize the potential for a third major approach—cooperative solutions. One important element in determining if an ES is a suitable candidate for cooperative solutions is the

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resource characteristics of the ES. Accordingly, this paper: 1) provides a framework for determining an ES's suitability for provision through collective management based on its resource characteristics, 2) provides an in-depth analysis of three agricultural-based ES to show how the framework differentiates between ES and 3) uses the framework to analyze fourteen select agricultural-based ES for their suitability for provision through collective management. Ten out of fourteen ES analyzed may be well suited (e.g. pollination), suited (e.g. flood control), or moderately suited (e.g. nature recreation) for provision through collective management under current incentive systems in agricultural ecosystems.

Keywords: ecosystem services, collective management, agricultural ecosystems, pollination services, carbon sequestration, nature recreation

1. Introduction

Agricultural ecosystems comprise about half of global land that is not desert, tundra, rock, or boreal, which makes farmers the chief managers of the most productive lands on Earth (Tillman et al., 2002). How farmers manage this land greatly impacts human health and well-being, the future productivity of the land, neighboring ecosystems such as wetlands and forest, and the sustainability of the world food supply (Foley et al., 2005; Horrigan et al., 2002). Despite this importance, most farmers face strong incentives to manage their land for the short-term production of food, fiber, or fuel. The long-term health of agricultural ecosystems, however, as well as their ability to sustain food production and to provide society with diverse benefits, requires that farmers expand their management focus to include the provision of ecosystem services (Goldman et. al., 2007; MEA, 2005; Swinton et. al, 2007). In fact, some scholars argue that one of the greatest needs in agriculture, if not the greatest, is the provision of non-production related ecosystem services (ES) such as water purification and climate regulation (e.g. Antle and Capalbo, 2001).

Most scholars agree that increasing the provision of ES in agricultural ecosystems will not be easy (e.g. Goldman et al., 2007). Robertson and Swinton (2005) called the need to increase ES provision in agricultural ecosystems “a grand challenge for agriculture,” while Lant et al. (2008) coined the underprovision of ES “The Tragedy of Ecosystem Services” in honor of Hardin (1968). Like Hardin, Lant et al. (2008) proposed that the solution to this tragedy is government control or privatization. In fact, most proposed solutions to the underprovision of ES in agricultural ecosystems involve common government or market approaches to provision of a public good (see Kroeger and Casey, 2007; Brauer et. al., 2006; Swinton et al., 2007 for an overview of government and market solutions).

A growing number of scholars, however, recognize the potential of a third major approach —cooperative solutions where landowners work together to provide ES (e.g. Sarker et. al., 2008.) Proponents of this approach often point to the spatial scale-mismatch between ES and agriculture as justification for its necessity (e.g. Goldman et al., 2007). In other words, the spatial scale of management in agricultural ecosystems (e.g. a 500 acre farm) often does not match the spatial scale of ecosystem processes necessary to provide high quality ES (e.g. a tri-county watershed), making cooperation necessary (Cummings et al., 2006; Pelosi et al., 2010). Like market and government solutions, cooperative solutions involve both costs and benefits to society that must be carefully examined to determine the most efficient, politically feasible, and socially feasible way to achieve a desired level of ES provision. One important step in this process is to determine which ES may be candidates for provision through cooperative solutions and which may not.

Previous studies involving cooperative solutions for ES provision in agriculture have focused on 1) a natural habitat type within agricultural landscapes, such as wetlands, that may be provided or restored using collective action and that, in turn, may provide a variety of ES (e.g. Hodge and McNally, 2000), 2) a single ES, such as water quality, which may be provided through collective management in certain situations (e.g. Sarker et. al., 2008) or 3) the need for land owners to cooperate to achieve landscape level benefits in providing ES (e.g. Goldman et al., 2007). Additionally, Ayer (1997) proposed that collective action may solve some agriculture-related environmental problems and discussed some factors which could make collective action a success or a failure in certain situations. No study, however, has analyzed ES for characteristics which may make some ES better suited than others for collective management. In fact, most previous studies make no or few distinctions between individual ES when discussing cooperative solutions for the provision of ES in agricultural ecosystems (e.g. Heal et al., 2001).

Resource characteristics are one of four key factors that influence the costs and benefits of the collective management of a natural resource, along with community characteristics, institutional characteristics and organizational characteristics (Ostrom, 1990, 2001; Lubell et al., 2002; Lubell, 2004). Important resource characteristics may include the size of the resource stock (e.g. physical size of a wetland), whether the stock is stationary or moving (e.g. a lake vs. a stream), the predictability of the resource flows (e.g. fish growth), or what type of benefit users may obtain from the resource (e.g. economic or cultural benefits) (Ostrom, 2001; Heikkila and Gerlak, 2005). Resource characteristics affect the likelihood that collective management will be undertaken and the likelihood that undertaking will be successful (Ostrom, 1990). The resource characteristics of an ES, therefore, may be an important element in determining whether or not it is a suitable candidate for provision by collective management.

Accordingly, my paper will: 1) Provide a framework for determining an ES's suitability for provision through collective management based on its resource characteristics, 2) Provide an in-depth analysis of three agricultural-based ES to show how the framework differentiates between ES and 3) Use the framework to analyze eleven other agricultural-based ES for their suitability for provision through collective management. This paper, however, will not provide a comparative analysis of government solutions, market solutions, and cooperative solutions for the provision of individual ES in agricultural ecosystems.

2. Background

<u>2.1 Ecosystem Services:</u> Ecosystems may be viewed as a form of natural capital which provides flows of vital goods and services to humans (e.g. Daily, 1997). These goods and services are called ecosystem services (ES) and are often defined as the "benefits people obtain either directly or indirectly from ecosystems (MEA, 2005)." Many ES are critical to human survival (e.g. climate regulation and water cycling), while others

contribute to our well-being (e.g. nature recreation and aesthetic landscapes) (Kremen, 2005).

Dale and Polasky (2007) identified three critical ways in which ES interact with agriculture. First, agricultural ecosystems provide many important ES, including production services such as food and fiber; regulating services such as soil retention and pest control; supportive services such as nutrient cycling and water filtration; and cultural services such as spiritual well-being and rural lifestyles (Table 2.1).

Second, agriculture requires many ES as inputs to production, especially soil fertility, pollination and pest control (Zhang et. al., 2007). Third, agriculture affects the quality and quantity of ES which other ecosystems, such as forests and estuaries, can provide (Dale and Polasky, 2007). If these effects on other ecosystems are negative, they are called "disservices" of agriculture and often lay on the opposite end of a continuum from some important ES (Table 2.1). For example, if a farmer practices conservation tillage, his land may provide the vital ES of soil retention. If, however, a farmer use conventional tillage practices on sloped land, his land may provide the opposing disservice of soil erosion, plus the resulting environmental degradation caused by stream sedimentation, loss of soil fertility, and the chemical contamination of water (Dale and Polasky, 2007).

As a result of these three ways in which agriculture interacts with ES—the ability to provide ES, the requirement of ES as inputs, and the ability to affect neighboring ecosystems' provision of ES—managing agricultural lands to provide more ES and higher quality ES has the potential to greatly increase the sustainability of agricultural ecosystems, to increase the sustainability of neighboring ecosystems, and to decrease the

Table 2.1. Selected Ecosystem Services (ES) and Disservices (ED) from Agriculture

ES Type	**ES from Agriculture**	**ES used as Inputs**	**ED from Agriculture**
Regulating Services	Soil retention	Soil retention	Soil erosion
	Pollination	Pollination	Competition for pollination
	Pest control	Pest Control	Pest outbreaks
	Water purification		Nutrient run-off Pesticide run-off
	Habitat provision		Habitat loss
	Atmospheric regulation		Greenhouse gas emissions
	Flood control		Flooding
	Seed dispersal		Loss of Seed Dispersal
Supporting Services	Soil structure	Soil structure	Soil compaction
	Soil fertility	Soil fertility	Soil fertility loss
	Biodiversity	Genetic biodiversity	Biodiversity loss
	Water cycling	Soil moisture	Soil moisture loss Competition for water from other ecosystems
	Nutrient cycling	Soil nutrients	Eutrophication of rivers, estuaries, and lakes
Cultural Services	Aesthetic landscape		Loss of aesthetic value
	Recreation		Loss of recreation value
	Spiritual well-being		Loss of well-being
	Rural lifestyles		Loss of rural culture and lifestyles
Production Services	Food		
	Fuel		
	Fiber		

Sources: Zhang et al., 2007; Tillman et. al., 2002; Swinton et. al., 2007; Dale and Polasky, 2007; Barrios, 2007; Millennium Ecosystem Assessment, 2005

environmental damage which often accompanies intensive agriculture (Tillman et al., 2002; MEA, 2005). Most scholars agree, however, that increasing the provision of ES in agricultural ecosystems will likely require society to change the incentive structure that farmers face (e.g. Swinton et al., 2007).

2.2 Incentive Structures in Agricultural Ecosystems: Incentive structure in most agricultural ecosystems encourage farmers to manage their land for the short-term production of food, fiber, or fuel, often at the expense of other ES (Tillman et. al., 2002; Swinton et al., 2007). For example, most farmers manage their land for the provision of production-related ES, such as wheat (Triticum spp.), because these services are private goods; the farmer enjoys most of the benefits of production (e.g. income from the crop) but does not pay all of the costs (e.g. loss of fishing income in a downstream community due to eutrophication of fisheries). Likewise, farmers disfavor the provision of cultural, supportive, or regulating ES, such as water purification, because the farmers pay all (or most) of the costs of provision (e.g. leaving land out of production next to a stream) but only enjoy a portion of the benefits (e.g. better bird watching on the farm). In some cases, farmers pay all of the costs of provision but receive no benefits because their efforts either have no discernible effect on the ES (e.g. one farmer's effort to improve water quality in a large lake) or because the ES is appropriated by other users (e.g. flood control for downstream communities).

Incentive structures where the provider pays all or most of the costs of provision but only receives a portion of the benefits are often associated with public or quasi-public goods, which is how most scholars classify ES (e.g. Swinton et al., 2007). This incentive structure often leads to the underprovision of ES because of the free-riding problem—if a person may enjoy the benefits of a good or service without paying for it, then the person has no incentive to pay for it (Olson, 1965). Most scholars agree that the way to solve the free-rider problem is through government or market solutions (e.g. Kroeger and Casey, 2007). In the case of agricultural-based ES, these solutions are designed to increase ES provision by changing the incentive structure that potential providers face. This may mean 1) increasing the cost of not providing an ES (e.g. assessing a fine if a farmer fails to create a buffer zone along a stream corridor), or 2) increasing the benefit of ES provision (e.g. creating a mechanism for farmers to receive price premiums on products that are produced in conjunction with ES) (Kroeger and Casey, 2007; Brauer et. al., 2006; Swinton et al., 2007).

The goal of most government and market solutions is to entice enough farmers to individually manage their land for the provision of nonproduction-related ES so that a socially-desired quantity of ES is achieved. One potential problem with these approaches, however, is that they often ignore the fact that many ES require landscape level management to provide optimal benefits (Goldman et al., 2007). In other words, individual incentive approaches to ES provision ignore the potentially large and important incentive of a collective benefit which only may be achieved if all or most of the farmers in the region cooperate in their management effort. It is in this context that the third approach to the free-riding problem, cooperative solutions, may become important to ES provision in agricultural ecosystems.

<u>2.3 The Collective Benefit of Collective Management:</u> Ostrom (1990) argues that collective management is a commonly-overlooked third solution to the underprovision of a natural resource. Collective management often involves a group of citizens who jointly manage a community-owned property, such as a group of herdsmen who work together to manage a community-owned pasture. It may also involve a group of citizens who jointly

manage their individually-owned properties, however, such as members of a neighborhood association who jointly make and follow rules regarding property appearance or noise levels in order to increase their enjoyment of their neighborhood.

When people work together for a common purpose they often achieve a collective benefit that could not be achieved by the group members' individual efforts. In fact, Olson (1965) argues that the possibility of achieving a collective benefit is the only incentive that people have to voluntarily form groups. In the collective management of a natural resource, most participants hope to achieve the collective benefit of a stable resource base—one that will continue to provide the resource indefinitely—although other collective benefits may also be achieved. For example, Berkes (1986) describes an inshore fishery in Alanya, Turkey which was threatened by hostilities, harvest uncertainty, and lost productivity because fishers were fighting over the most productive fishing spots. In response, members of the local fishing cooperative devised a set of rules for managing the fishery which assigned fishing spots to the local fishers on a daily basis, giving each fisher an equal chance to fish highly productive spots and less productive spots. This collective management regime, enforced by the fishers themselves, created a more productive fishery since better spacing of the fishers optimized the production capability of each site. In addition, individual fishers no longer wasted resources searching for or fighting over sites, plus they achieved more harmonious relationships within their community. Each of these benefits represents a collective benefit that the fishers could not have achieved by the fishers' individual efforts. These collective benefits were only achieved because the fishers worked together to devise and enforce a set of rules for managing the local fishery (Ostrom, 1990).

In the collective management of an ES, participants may also hope to achieve the collective benefit of enhanced ES provision, environmental damage mitigation, or the prevention of future regulations (e.g. Lubell, 2004). For example, Ayer (1997) describes a group of cotton (Gossypium spp.) farmers in Arizona who collectively managed their crop land for the ES pest control by practicing collective integrated pest management (IPM)—a management system that requires monitoring pest populations and only applying pesticides when a certain threshold is reached. After devising and enforcing a set of collective IPM rules, these farmers achieved fewer pest outbreaks, drastically reduced input costs, and fewer confrontations with neighboring communities regarding water quality and air quality issues— benefits that were only achieved when most of the cotton farmers in a region worked together to enhance the ES of pest control (Ayer, 1997).

3. Framework

Ayer's (1997) example of collective IPM in a cotton-farming region in Arizona illustrates the potential for collective management to provide an increased quantity and quality of the ES, pest control, along with other socially and economically important collective benefits. To determine which other ES may be candidates for provision through collective management, society needs a way to assess ES for their collective management suitability. Accordingly, I have developed a framework for analyzing agricultural-based ES for resource characteristics which could enhance or detract from collective provision.

To develop this framework, I reviewed collective action theory and empirical research for key elements that make collective action or collective management of a natural resource more likely to happen or to succeed. These key elements include the potential for positive net benefits to participants through cooperation, a low heterogeneity of participants, opportunities for face-to-face communication of participants, a low number of participants, social linkages between participants, and information about participants' past actions (Ostrom, 1990, 2001, 2009; Olson, 1965). Next, I used these key elements to identify six characteristics of ES that may affect their suitability for collective management. These characteristics are:

1.) Potential for enhancement of ES quality or quantity by landscape level management.
2.) Potential for direct private benefits for the ES providers (i.e. the ES is important to the provider)
3.) Potential for indirect private benefits for the ES providers (i.e. the ES is important to other potential appropriators who will pay for its provision.)
4.) Potential to bundle ES provision with the provision of other ES
5.) Number of participants needed to provide or enhance ES (i.e. how much well-managed land is required to provide the ES).
6.) Heterogeneity of participants needed to provide or enhance ES.

After identifying these six characteristics, I devised a classification system to assess whether an ES possesses that characteristic in a high, moderate, or low quantity. In addition, I developed a ranking system based on these classifications to assess the overall suitability of an ES for provision through collective management. In the following sections, I provide an in-depth discussion of the characteristics along with a justification for my classification system.

3.1 Enhancement Potential of ES through Landscape Level Management: Collective action theory predicts that people will only act collectively to provide benefits which are enhanced or increased through cooperation (Olson, 1965). In other words, if a benefit can be provided adequately through individual effort, then it will not be provided collectively (Olson, 1965).

ES vary greatly in their enhancement potential through landscape level management as opposed to individual farm level management (Tscharntke et al., 2005). A few ES, such as soil structure, may provide benefits to individual land managers at levels that are high enough to make landscape level management unnecessary or undesirable. In other words, how one farmer manages his land usually does not affect the soil structure services that are available on another farmer's land (with a few exceptions, such as poor management of highly erodible soils—White and Runge, 1994). Most ES, however, require landscape level management to provide optimal benefits (Heal et al., 2002; Tscharntke et al., 2005). These ES may require management over a large area, a specific landscape configuration, or both (Goldman et al. 2007; Tscharntke et al., 2005). For example, pest control services depend on the species richness and abundance of pest predator species, which in turn depend on the quantity, quality, and landscape configuration of breeding, resting and foraging habitat in the region (Dale and Polasky, 2007). Thus, a typical Midwestern farmer with a 550 acre farm (Archer et. al., 2002) may not be able to set-aside enough habitat to support a population of pest predators and still grow crops, but the habitat provision efforts of many farmers working together may support multiple predator populations and in turn, enhance pest control in the region.

In my framework, I classify an ES as having a high potential for enhancement through landscape level management if the quantity, quality and stability of the ES depend on a specific configuration of management activities over a land region larger than a single farm. In other words, I classify the ES as "high" if the management activities of a farmer's neighbors greatly affects the farmer's ability to provide the ES (e.g. flood control), and I classify the ES as "low" if the management activities of a farmer's neighbors have little or no effect on a farmer's ability to provide the ES (e.g. soil fertility) (Table 2.2). ES that are classified as "high" are most suitable for provision through collective management, although some that are classified as "moderate" (e.g. soil retention) may also be suitable for collective management in some situations (White and Runge, 1994).

<u>3.2 Potential for Direct Private Benefits:</u> Collective action theory and empirical research show that if participants believe they will gain more from participation in collective action than their participation will cost, then they will participate (e.g. Olson, 1992; Loehman and Dinar, 1994). Although the net benefits depend on each provider's unique situation and, therefore, cannot be easily determined, it is likely that those ES with a high potential to supply direct private benefits to the ES provider are more likely to supply a net benefit than those with a low potential. Direct private benefits may include: 1) direct economic benefits, such as increased crop yields due to increased soil fertility and

Table 2.2 Analysis of agricultural-based ecosystem services (ES) for their suitability for provision through collective management by using a classification framework based on the characteristics of the ES that may enhance collective action.

Ecosystem Service	Potential for Landscape Level Enhancement	Direct Benefit Potential For ES Providers	Importance to Other Potential Appropriators	Potential to Bundle With Other ES***	Number of Providers Needed to Enhance ES	Heterogeneity of Providers Needed to Enhance ES	Suitability for Collective Management
Pollination	High	High	Moderate/Low	PestControl,Habitat	Low	Low/Moderate	Highly suited
Pest Control	High	High	Moderate	Pollination,Habitat	Low	Low/Moderate	Highly suited
Flood Control	High	Low *	High	Habitat, soil –related ES	Moderate/ High	High	Suited
Water Purification	High	Low/ Moderate*	High	Soil-related ES, Most other ES	High**	High	Suited
Recreation	High	Moderate	Moderate	Habitat	Moderate	Moderate	Moderately Suited
Biodiversity	High	Low	Moderate	Habitat Recreation	High	High	Moderately Suited
Habitat Provision (mega fauna)	High	Low	Moderate	Recreation Biodiversity	Moderate	Moderate	Moderately Suited
Aesthetic Landscapes	Moderate/ High	Moderate	Moderate	Recreation	Moderate	Low/Moderate	Moderately suited
Habitat Provision (other spp.)	Moderate/Low	Low	Low	Biodiversity	Low/Moderate	Low/Moderate	Not suited
Soil Retention	Moderate/Low	High	Moderate/ High	All soil-related ES	Low/ Moderate	Low/Moderate	Moderately suited to not suited
Soil Fertility	Low	High	Low	All soil-related ES	Low	Low	Not suited
Soil Structure	Low	High	Low	All soil-related ES	Low	Low	Not suited
Carbon Sequestration	Low	Moderate	Moderate	All soil-related ES	Low	Low	Not suited

Highlighted classifications represent the characteristic that corresponds to the greatest suitability for provision through collective management.

*Provider of this ES is often not the appropriator.

**ES may be provided by individual land owners, yet the good associated with this ES requires a high level of participation in a potentially large geographical region (e.g. water quality is the good associated with water purification).

***This column includes ES that are also provided at high levels in agricultural ecosystems when the main ES is provided at high level.

2) direct social or cultural benefits, such as increased wildlife viewing or hunting opportunities due to habitat provision.

Ecosystem services vary greatly in the direct benefits that they can supply to ES providers. Some ES are inputs to agriculture (e.g. pollination) and can be produced jointly with agricultural goods such as wheat (Wossink and Swinton, 2007). These ES supply the provider with the direct economic benefits of lower input costs and increased crop yields, and are more likely to be provided than other ES (Wossink and Swinton, 2007). In contrast, other ES supply little direct economic benefit to the provider (e.g. flood control services), although the same ES may provide substantial economic benefits to other appropriators (e.g. down-stream municipalities). Additionally, ES vary greatly in the social and cultural benefits they may provide, especially since the value of these benefits are subjective and personal (e.g. the value a farmer places on seeing or hunting a bird that he has provided habitat for differs greatly from one farmer to the next).

In my framework, I classify all ES which are inputs to agriculture as having a "high" potential to provide direct private benefits to providers (e.g. soil fertility) (Table 2.2). I classify an ES as "moderate" if it has a small potential for economic benefit, but a high potential for cultural or social benefits (e.g. nature recreation), and I classify an ES as "low" if it only has valuable to the provider in the same measure as it has value to all members of society (e.g. carbon sequestration). ES that are classified as "high" are most suitable for provision through collective management, although those that are classified as "low" or "moderate" may also be highly suitable for collective management if the ES has a high potential to supply indirect benefits to the ES providers.

3.3 Potential for Indirect Private Benefits: If an ES is important to appropriators other than the providers, the providers may receive an indirect private benefit. For example, farmers may receive a payment for environmental services (PES) for setting aside agricultural land in a manner that increases ES provision (e.g. conservation reserve land). Other examples of indirect benefits may include payments for the provision of flood control, hunting leases for access to private land with wildlife habitat, avoidance of water contamination fines due to water purification services, or avoidance of threatened regulations due to water purification services (Hoffman, 2008; Salzman et al., 2001; Knoche and Lupi, 2007). Indirect benefits increase the total benefits available to ES providers, which in turn increase the net benefits for providers and the likelihood the ES will be provided through collective action (Olson, 1965).

In my framework, I classify ES which have a high economic importance to appropriators other than the providers as having a "high" potential for indirect private benefits (e.g. flood control) (Table 2.2). I classify ES as "moderate" for this characteristic if it has a high cultural or social importance to other appropriators (e.g. nature recreation). I classify all other ES as "low" (e.g. soil fertility). ES that are classified as "high" are most suitable for provision through collective management, although those that are classified as "low" or "moderate" may also be suitable if the ES has a high potential for direct benefits to the ES providers.

3.4 Potential to Bundle ES Provision: Many ES are so interrelated that it is hard to distinguish one from the other or to define them (Dale and Polasky, 2007; Swinton et al., 2007). For example, soil retention, soil structure, and soil fertility are interrelated in complex ways and could be lumped together into one ES called soil services. Likewise, soil fertility is already a conglomeration of many ES, including dung burial, habitat for microorganisms, nutrient cycling, soil aeration, and soil moisture (Swinton et al., 2007; Barrios, 2007). Because of the interrelatedness of ES, it is also hard to manage for one ES without enhancing the provision of another. For example, leaving a buffer zone along a stream corridor to enhance water quality also enhances pollination, pest control, nature recreation, habitat provision, biodiversity, and soil-related ES.

Bundling the provision of one ES with another has been proposed as a way to increase ES provision although it is considered an imperfect solution (Chan et al., 2006). Bundling ES provision could increase the likelihood a collective management solution will be undertaken or succeed because it increases the potential benefits to ES providers. For example, if farmers know that participating in collective IPM will enhance pollination as well as pest control, then they may be more likely to cooperate. Likewise, if a group has already formed to provide one ES, then it may be able to increase its collective benefits with few additional costs by providing a second ES.

Because all ES have the potential to be bundled with the provision of other ES, I do not use the classifications of high, medium or low for this characteristics in my framework. Instead, I list other ES that are often provided at high levels when the main ES is provided at high levels (Table 2.2). For example, if a famers' cooperative provides a high level of biodiversity, then it most likely provides a high level of habitat as well. Likewise, if a group of landowners provide high water quality through watershed protection, then they usually provide flood control, too (Salzman et al., 2001).

3.5 Number of Participants Needed: Collective action theory predicts that collective action is more likely to be successful (or to occur at all) when the number of participants is small (Olson, 1965; Ostrom, 2009). Small groups may be more effective because 1.) they face lower transaction costs (e.g. fewer people must agree on proposed actions), 2.) individual participants are more likely to see the effect of their own contribution and to consider it valuable (Olson, 1965) and 3.) face-to-face communication among participants is more likely (Ostrom, 2009).

Although small groups may be desirable, in the case of natural resource management a moderate size group may be needed to provide enough resources (e.g. land) to achieve an enhanced collective benefit (Agrawal, 2000). As discussed in section 3.2, many ES are enhanced in both quality and quantity by landscape level management. They differ greatly, however, in the land area required. For example, pest control is considered a local service (Kremen, 2005) and may be enhanced by a small number of farmers (perhaps as few as 10-25, depending on farm size) who own farms in close proximity. Although a larger number of participants over a greater land area may increase the collective benefit of pest control services (by decreasing the odds of regional pest outbreaks), cooperative benefits are possible with a relatively small number of participants. On the other hand, some ES require a larger land area (and, thus, most likely a larger number of participants) to provide enhanced cooperative benefits. For example, the service of flood control is considered a regional service (Kremen, 2005) and may depend on the cooperative efforts of landowners in a tri-county (or tri-state) watershed (Salzman et al. 2001).

In my framework, I classify local ES (those that may be enhanced by a group of less than 25 farmers) as "low," those that may be enhanced by the collective efforts of up to about 100 participants as "moderate," and regional or global ES (those that require hundreds, perhaps thousands of participants) as "high" (Table 2.2). ES that possess a relatively low participation requirement may be easier to provide through collective management (e.g. pollination) than those with a high participation requirement (e.g. water quality).

3.6 Heterogeneity of Participants Needed: Collective action scholars disagree whether heterogeneity increases or decreases the likelihood of successful collective action. Olson (1965) argues that when one or a few individuals have a much stronger interest in a collective good it has a greater chance of being supplied. Most other scholars, however, argue that heterogeneity decreases the ability of participants to cooperate and increases their transaction costs (e.g. Johnson and Libecap, 1982). Heal et al. (2001) claim that "the larger the number of political entities required to make a decision, the greater the costs of collective action and, therefore, the less likely action will be taken." In other words, ES which require larger and more diverse land areas for their provision, and therefore involve a more diverse group of political actors, will be harder to provide through collective management.

Heterogeneity is also hard to define in the context of collective management of agricultural ecosystems. The least heterogeneous group possible in an agricultural ecosystem might include farmers that live in the same township and grow the same crop, such as wheat. A more heterogeneous group might include all the wheat farmers, dairy farmers, and orchardists within the township. However, this group could also be defined as homogenous, since each member is a farmer who lives in same geographical area. Furthermore, groups that include only farmers may benefit from the high social capital that often exists in rural communities (Onyx and Bullen, 2000). Numerous social links between participants, knowledge of participants' past actions, and other aspects of social capital, such as trust, are important in determining if collective action will be successful (Ostrom, 1990; Pretty, 2003).

In the case of ES, a relatively homogenous group could supply some ES, while others may require cooperation between people of very diverse backgrounds. For example, a group of farmers working together could supply pest control services for their own appropriation, but it may take a diverse group of people (e.g. farmers, developers, suburban land-owners, and factory owners) to supply water quality (Hoffman, 2008). Likewise, ES that require a larger land area for provision (e.g. flood control) are more likely to require a more heterogeneous group of providers to supply the ES.

In my framework, I classify an ES as requiring a "low" heterogeneity of participants if the ES can be provided by a group of farmers working together in relatively small geographic area (Table 2.2). I classify an ES as requiring a "high" heterogeneity of participants if diverse groups of people (such as farmers and factory owners) over a large area are needed for provision (Table 2.2). ES that require "low" heterogeneity of participants (e.g. aesthetic landscapes) may be more suitable for collective management than ES that require a "high" heterogeneity of participants (e.g. biodiversity).

3.7 Overall Suitability Rankings: By using my classification system for the six characteristics, I developed a ranking system that summarizes the overall suitability of an ES for provision through collective management (Table 2.2). The five ranking categories range from "highly suited" to "not suited" and are based on the following hierarchal ordering of the resource characteristics.

1.) Potential for enhancement of the ES by landscape level management.
2.) Potential for direct and/or indirect private benefits for ES providers
3.) Potential to bundle ES with the provision of other ES.
4.) Number and heterogeneity of participants needed to provide or enhance ES.

The potential for enhancement through landscape level management is first in the hierarchical orderings because according to collective action theory, the potential to supply a collective benefit is a necessary but not sufficient condition for collective action success (Olson, 1965). Second in the orderings, the collective benefit should include a net benefit to participants (i.e. potential for direct private benefits, potential for indirect private benefits and, to a lesser extent, the ability to bundle provision of ES with another ES) (Olson, 1965; Ostrom, 2009; Loehman and Dinar, 1994). Finally, the transaction costs that arise through greater participant number and participant heterogeneity may be overcome by high net benefits (White and Runge, 1994), so these characteristics are ordered last.

To receive the ranking "highly suited" for provision through collective management, an ES must have 1) a high potential for landscape level management, 2) a high potential for either a direct or indirect private benefit, 3) the potential to be bundled with at least one other ES, and 4) a low or moderate participant number and heterogeneity needed. To receive the ranking “suited” the ES must meet the same requirements above except it may require a high number or high heterogeneity of participants. To receive the ranking “moderately suited,” the ES must have 1) a high or moderate potential for enhancement through landscape-level management, 2) at least a moderate potential for either a direct or indirect private benefit, 3) the potential to bundle with another ES and 4) a low or moderate number and heterogeneity of participants. To receive the ranking “poorly suited,” the ES must have 1) a moderate potential for landscape level enhancement, 2) at least a moderate potential for either direct or indirect benefits 3) no bundling potential and 4) at least one moderate or low classification for number or heterogeneity of participants (i.e. one may be high). All other ES receive the ranking, “not suited,” including all ES that have a low potential for landscape level enhancement.

4. Application of the Framework

After developing my framework, I used it to analyze fourteen agricultural-based ES to assess their suitability for provision through collective management. In the following section, I provide an in-depth analysis of three ES to show how the framework differentiates between the ES in determining suitability. Afterwards, I summarize my results for the remaining eleven ES.

<u>4.1 Pollination Services Background:</u> In the United States, almost 90 crop species rely on pollination by the non-native honeybee (Apis mellifera)—a service valued at an estimated 18 billion dollars per year (Sanford, 1998). Native bees also provide several million dollars of pollination services to U.S. farmers each year, as do other pollinating insects, birds and bats (Sanford, 1998; Gallai et al., 2009). Recent trends in agricultural

intensification, habitat loss, and pesticide use, however, have depleted wild pollinator and commercial honeybee populations (Kremen et al., 2002; Steffan-Dewenter et al., 2002; Johansen, 1977). Additional factors such as disease, colony collapse disorder, malnutrition, mite infestation, Africanization, and the elimination of honey subsidies have also contributed to the decline in bee colonies—a decline many scholars call "the pollination crisis" (VanEngelsdorp et al., 2009; Nabhan and Buchman, 1997).

Pollination services may be promoted in agricultural ecosystems by following such management practices as interspersing cropland with patches of native or semi-native habitat, providing season-long floral resources (e.g. planting wildflowers or shrubs that bloom before or after crops), and reducing or eliminating pesticide application (Brosi et al., 2007; Fussel and Corbet, 1992; Kearnes et al., 1998; Parker et al., 1987). For example, Kremen et al. (2002) found that native bee communities could provide full pollination services for watermelon, a crop with heavy pollination requirements, without the intervention of managed honeybees on organic farms located near natural habitat. All other farms in the study (i.e. farms that used pesticides or were not located near native habitat) required commercial pollination services to sustain desirable yields (Kremen et al., 2002).

4.2 Analysis of Pollination Services for Collective Management Suitability:

4.2.1 Potential for enhancement of pollination services by landscape level management—High. Many scholars believe landscape level management is important, if not essential, for the provision of pollination services (e.g. Goldman et al., 2007; Steffan-Dewenter, 2003). For example, a population of bees may require either one large patch of native habitat or many small patches of rest and breeding habitat arranged in an optimal configuration over a larger landscape. A typical Midwestern farmer (farm size 550 acres) most likely will not be able to set aside enough land to support the population and still produce crops. If many farmers in the region, however, work together to set aside a few habitat patches each in an optimal configuration, then larger, healthier, and more diverse populations of pollinators may be supported, increasing the quantity, quality and stability of pollination services in the region.

4.2.2 Potential for direct private benefits for pollination service providers—High. Pollination is a required input to production for many crops. Thus, providers may benefit directly by: 1) an increased effectiveness of commercial pollination, 2) a reduced need for or an elimination of commercial pollination, 3) increased yields, 4) stable pollination during times of reduced commercial or hobby bee-keeping {e.g 40% loss of colonies due to colony collapse disorder in 2007 alone (VanEngelsdorp et al., 2008)}, and 5) pollination of gardens and orchards kept for home production (Nabhan and Buchman, 1997; Kremen et al., 2002; Kremen, 2005).

4.2.3 Potential for indirect private benefits for pollination service providers—Low. Few people have a high interest in pollination services besides potential providers, although people who keep bees for commercial or home honey production may provide an indirect benefit to some farmers. Bee-keepers are technically providers (not non-providing appropriators) since they provide breeding and resting habitat for honeybees. However, they rely on other providers to supply hospitable foraging habitat so their bees may produce high-quality honey. Accordingly, it is common practice for a bee-keeper to locate hives on a farmer's land, often in exchange for a small payment of cash or honey to the farmer, although some bee-keepers combine honey production with commercial pollination services and charge the farmer a fee instead.

4.2.4 Potential to bundle pollination services with the provision of other ES- pest control. Pest predator populations (mostly birds and insects) may be enhanced by interspersing cropland with native or semi-native habitat patches and by practicing integrated pest management (Dale and Polasky, 2007), two of the three recommended management practices for pollination services. Thus, farmers who provide a high level of pollination services should also provide a high level of pest control.

4.2.5 Number of participants needed to enhance or provide pollination services—Low to Moderate: Pollination services are a local service, although the amount of land needed to provide high quality pollination services may depend on the region, the crops involved, local landscape configurations, the pollinating organisms involved, and farm size (Kremen, 2005). In many situations, as few as 5-25 farmers/land-owners working cooperatively could achieve the collective benefit of enhanced pollination services. In other situations, such as in a region intensely managed for the production of crops at the exclusion of natural habitats, greater than 25 providers may be needed.

4.2.6 Heterogeneity of participants needed to enhance or provide pollination services—Low to Moderate: Although pollinating organisms require landscape level management, pollination services may be provided without requiring people of vastly different cultural backgrounds and needs to agree on a management plan (e.g. farmers, politicians, and developers). In most situations, a relatively homogenous group of farmers from the same region could work collectively to achieve a greater benefit than they could have each achieved by their individual efforts. Collective management of pollination services may be most suitable in areas where many, if not most, of the farmers require some pollination services (i.e. they are homogenous in their needs as well as their cultural background). In regions where farmers who need pollination services are interspersed with farmers who do not, a more heterogeneous group of farmers may be required.

Pollination has a high potential for enhancement through landscape-level management, a high potential for direct private benefits for providers, may be bundled with pest control, and requires a low to moderate number and heterogeneity of participants. Thus, pollination is highly suited for collective management.

4.3 Recreation Background: Recreation in agricultural ecosystems may involve consumptive uses (e.g. hunting) or non-consumptive uses (e.g. nature photography) (Swinton et. al., 2007; Knoche and Lupi, 2007). Thus, to provide recreation, agricultural ecosystems must support animals and plants that people like to hunt, view, or photograph. In addition, agricultural ecosystems must provide these animals and plants in a way that provides recreational satisfaction. Satisfaction may depend on species abundance, species richness, visibility of animals or plants, places to stop and view wildlife, hunting or fishing success, low density of people, water quality, landscape aesthetics, and whether or not recreation expectations were met (Hammit et al., 1993; Decker et. al., 1980; Stankey et al., 1973; Graefe and Fedler, 1973).

Accordingly, recommended management practices include practices that increase species richness, species abundance, or water quality such as restoring marginal lands to their original cover (e.g. native grass) or to other perennial vegetation, establishing grassed waterways, establishing hedge rows or woody fence rows, increasing structural diversity of crops, increasing structural diversity of farmstead vegetation, delaying mowing of hay crops and headlands, and planting buffer zones in riparian areas (OECD, 1999; Stallman and Best, 1996; Freemark, 1995; Camp and Best, 1993; Bryan and Best, 1991).

4.4 Analysis of Recreation for Collective Management Suitability:

4.4.1 *Potential for enhancement of recreation by landscape level management—High.*

Species richness, species abundance and water quality depend on the quantity and type of management activity practiced and the spatial configuration of this activity within the landscape (Kremen, 2005; Goldman et al., 2007). Thus, recreation experiences where satisfaction depends on an abundance of one species (e.g. quail hunting), on a high level of species richness and abundance (e.g. bird watching) or on water quality (e.g. fishing or swimming) may be enhanced by landscape level management.

4.4.2 *Potential for direct private benefits for recreation providers-Moderate.* Recreation has a high potential to provide a direct cultural value or well-being to providers but a low potential to provide a direct economic benefit.

4.4.3 Potential for indirect private benefits for recreation providers—Moderate. Recreation providers may achieve the indirect private benefit of hunting or fishing leases although benefits may vary greatly with region and species of interest (Knoche and Lupi, 2007). For example, Livengood (1983) reports hunting lease rates in Texas that range from $100-200 annually per gun, while Hussain et al. (2004) reports that hunters in Kansas are willing to pay $31.32/year for hunting leases. Additionally, increased crop damage by game animals may outweigh the indirect benefits achieved through hunting leases (Knoche and Lupi, 2007).

4.4.4 Potential to bundle recreation with the provision of other ES—Habitat for megafauna. To provide many satisfying recreational experiences farmers must also provide habitat for animals such as birds and fish.

4.4.5 Number of participants needed to enhance recreation—Moderate. The land area and spatial configuration of management activities that are required to enhance the quantity or quality of recreation depend on the recreation being provided. As few as 5-20 participants may be able to provide enhanced wildflower viewing along a country road, while hundreds of participants may be needed to provide a high quality stream fishing experience (i.e. to provide fish habitat and high water quality).

4.4.6 Heterogeneity of participants needed to enhance or provide recreation—Moderate. Provision of high quality recreation services may require a diverse group of providers to cooperate (e.g. lake boating) or may be achieved by a relatively homogenous group of farmers (e.g. sight-seeing to view fall colors).

Recreation has a high potential for enhancement though landscape level management, but only a moderate potential for direct or indirect private benefits for providers. Thus, recreation is moderately suited for collective management.

4.5 Carbon Sequestration Background: Increases in the atmospheric abundance of CO_2 and other greenhouse gases have led many scientists and policy-makers to identify strategies to stabilize the atmosphere and to mitigate climate change (Lal, 2004a). One strategy, carbon sequestration, is considered a win-win strategy that "will not solve the problem but buys us time until alternatives to fossil fuel are in effect" (Lal, 2004b). Carbon sequestration involves transferring atmospheric CO_2 into long-lived pools (e.g. forests) and storing it securely so it is not immediately re-emitted.

An important source of carbon sequestration for farmers is improving soil organic carbon (SOC) (Lal, 2002a; West and Post, 2002). This may best be achieved through adoption of recommended management practices such as conservation tillage with cover crops and crop residue mulch, nutrient cycling with compost and manure, biologically efficient irrigation and other water conservation practices, rotation cropping, restoring marginal lands to their original cover or other perennial vegetation, practicing agroforestry, and planting windbreaks and other woody vegetation around farmsteads and in hedgerows (Lal, 2004a, 2004b).

4.6 Analysis of Carbon Sequestration for Collective Management Suitability:

4.6.1 *Potential for enhancement of carbon sequestration by landscape level management—Low.* Although climate regulation is a global issue, carbon sequestration may be provided by individual farmers who follow recommended management practices (Lal, 2007). In other words, one farmer's management practices have little effect on a neighboring farm's SOC, except in the case of highly erodible soils where failure to retain soil on one farm may affect another farmer's ability to retain soil (White and Runge, 1994).

4.6.2 *Potential for direct private benefits for providers-Moderate.* Although providers of carbon sequestration only benefit from climate regulation in the same proportion as all humans, increased SOC also increases crop production (Lal, 2004a; West and Post, 2002).

4.6.3 *Potential for indirect private benefits for providers—Moderate.* Because mitigating climate change is important to governments, environmental groups, and other individuals, carbon sequestration providers may have the potential to gain an indirect private benefit. Lal (2007) states that once carbon is sequestered in the soil, it can be traded like any other commodity. Thus, farmers may literally be able to "farm carbon" and sell it in a carbon market.

4.6.4 *Potential to bundle carbon sequestration with the provision of other ES – All soil-related ES.* The same management practices that improve SOC also provide soil fertility, soil retention, and soil structure (Lal, 2004a; West and Post, 2002).

4.6.5 *Number of participants needed to enhance or provide carbon sequestration—Low.* Carbon sequestration may be provided by individual farmers (Lal, 2007).

4.6.6 *Heterogeneity of participants needed to enhance or provide pollination services—Low*. Carbon sequestration may be provided by individual farmers (Lal, 2007).

Carbon sequestration has a low potential for enhancement through landscape level management, a necessary condition for suitability for cooperative solutions. Thus, carbon sequestration is not suited for collective management.

<u>4.7 Analysis of Other ES for Collective Management Suitability:</u> The results for my analysis of eleven other agricultural-based ES are summarized with the above results in Table 2.2. Two of the fourteen ES, pollination and pest control, are highly suited to provision through collective management. Two more, water purification and flood control, are suited to collective management provision, while another five (recreation, biodiversity, habitat for mega fauna, aesthetic landscapes, and soil retention) are moderately suited. The final four ES (habitat for micro fauna, soil fertility, soil structure, and carbon sequestration) were not suited for provision through collective management because of a low potential for landscape level enhancement (i.e. could be provided as effectively by individual land managers).

5. Discussion

In the development of my framework, I identified one resource characteristic—the potential for enhancement through landscape level management—which is essential for determining whether or not an ES may be a candidate for collective provision in agricultural ecosystems. Without this potential, a substantial collective benefit is unlikely to occur, giving farmers little or no incentive to participate in a group activity with potentially high transaction costs (Olson, 1965). In my analysis, four out of fourteen ES were not suited for collective management based on this resource characteristic. Thus, society must consider resource characteristics, especially the potential for enhancement through landscape level management, when choosing how to approach the ES underprovision problem.

The remaining five characteristics in my framework help differentiate between ES that are good candidates for provision through collective management and those that are marginal candidates. These characteristics are concerned with the benefits and costs of collective management and help determine the likelihood that farmers will voluntarily provide the ES through collective action. Unlike with the first characteristic, an unfavorable classification for any of these characteristics may be overcome depending on the context and regional importance of the ES. For example, White and Runge (1994) found that those farmers who received a direct economic benefit were more likely to participate in collective action to control erosion in a watershed in Haiti than those who did not, but direct economic benefits were not the only indication of who would participate in the project. In other words, direct economic benefits were an important but not a necessary incentive for participation. Likewise, in the 1990's water quality issues became so important in New York City that diverse citizens in the neighboring rural counties were able to overcome problems of heterogeneity, a large number of participants, and a lack of direct benefits in order to supply the city with higher water quality and themselves with the indirect benefit of escaped regulatory pressure (Hoffman, 2008; Salzman et al., 2001.)

Regional importance of the ES may in fact be one of most important factors in determining the likelihood of successful collective management. For example, Ayer (1997) reports that in years of extreme pest problems, cotton farmers in Arizona successfully managed pests through the creation of pest management districts which practiced collective IPM on a regional scale. When pest problems dissipated, however, interest in the districts also dissipated and many did not survive (Ayer, 1997). This example re-emphasizes an earlier point that many agricultural ecosystems are managed for short-term production gains, not long-term sustainability such as stable pest populations. It also points to an overarching problem that despite suitability for provision through collective management, few ES are being provided this way under the current incentive structures in agriculture.

Sandler (1992, pg. 18) claims that "in the real world some forms of collective action come naturally, while other forms need government intervention." Likewise, many scholars propose that society needs to create more policies that provide incentives for people to cooperate in the provision of ES (e.g. Goldman et al., 2007). In fact, some scholars claim that government policies which induce cooperation may be the most cost effective way to provide some natural resources, including ES (e.g. Hodge and McNally, 2000). In other words, the most effective approach for addressing the provision problem of ES in agricultural ecosystems may be a combination of the three major approaches—government solutions, market solutions, and cooperative solutions.

Most proposed policies that are aimed at combining two or three of the major approaches are designed to induce voluntary cooperation among providers. Three examples are the 1) agglomeration bonus which was designed to create larger patches of continuous habitat within single farms and across private boundaries (thus providing a higher quality and quantity of ES) by giving landowners an additional payment for each acre of land retired that shares a common border with another retired acre (Parkhurst et al., 2002), 2) the cooperation bonus which was designed to make sure that the most important land for ES provision is retired and expands on the idea of the agglomeration bonus by giving landowners an extra payment for each acre of land retired that borders a natural resource, such as a river, as well as a neighbor's retired land (Goldman et al., 2007) and 3) the entrepreneur incentive which encourages landowners to cooperate in creating and implementing their own landscape design for ES provision by funding the projects that are judged most feasible and effective (Goldman et al., 2007). A fourth proposed policy, however, includes an element of coercion which Olson (1965) predicts will increase the likelihood that collective action succeeds. ES districts would have the legal power to manage natural resources in agricultural ecosystems by using a combination of voluntary incentives such as those described above and regulations (Parkhurst and Shogren, 2007; Goldman et al. 2007; Heal et al., 2001).

This paper fills a gap in the literature by identifying which ES may be good candidates for collective management and which may not. Research is needed, however, to compare the costs and benefits of each major approach and the combined approaches to ES provision. Additionally, more research is needed to determine what policies and incentives may best induce collective management of ES in agricultural ecosystems.

6. Conclusion

Although the recent trend in agricultural intensification in Western cultures has caused a decrease in the provision of ES in agricultural ecosystems (Björklund, 1999;

Tilman et al., 2002), a third major approach to the free-rider problem—collective management of ES—may help to reverse this problem. My analysis shows that many ES have characteristics that make them highly suited, suited, or moderately suited for provision through collective management, indicating that collective management may be a viable alternative to government or market solutions for some ES. Holling and Meffe (1996) argue that command and control is often an undesirable way to manage natural resources, claiming that command and control solutions lead to a pathology in management that decreases the quality and quantity of resources supplied. Likewise, numerous examples exist in which natural resources were seriously degraded when privatized or put under government control (e.g. Thomson et al., 1986; Arnold and Campbell, 1986). Instead of fully relying on these common solutions to the free-rider problem—privatization or government control—collective management provides an important alternative which has worked to provide stable natural resources in numerous long-term situations (Ostrom, 1990) and may also work to provide ES in agricultural ecosystems.

7. References

Agrawal, A. 2000. Small is beautiful, but is larger better? Forest-management institutions in the Kumaon Himalaya, India. Pg. 57-86 in People and Forests: Communitities, Institutions, and Governance, eds. C. Gibson, M. McKean, and E. Ostrom. Cambridge, Mass.: MIT Press.

Antle, J. M, and S. M Capalbo. 2002. Agriculture as a managed ecosystem: policy implications. *Journal of Agricultural and Resource Economics* 27.

Archer, D., J. Pikul, and W. Riedell. 2002. Economic risk, returns and input use under ridge and conventional tillage in the northern Corn Belt, USA. *Soil and Tillage Research* 67:1–8.

Arnold, J. E. M., and J. G Campbell. 1985. "Collective management of hill forests in Nepal: the community forestry development project." in *Proceedings of the Conference on Common Property Resource Management, April 21-26, 1985*.

Ayer, H. W. 1997. "Grass roots collective action: agricultural opportunities." *Journal of Agricultural and Resource Economics* 22:1–11.

Barrios, E. 2007. Soil biota, ecosystem services and land productivity. *Ecological Economics* 64:269-285.

Batie, S. 1997. Environmental benefits resulting from agricultural activities: The case of non-European OECD countries. Pp. 81–102 in *Environmental Benefits from Agricultural Issues and Policies: The Helsinki Seminar*.

Berkes, F. 1986. Local level management and the commons problem: A comparative study of Turkish coastal fisheries. *Marine Policy* 10:215-229.

Björklund, J., K. E. Limburg and T. Rydberg. 1999. Impact of production intensity on the ability of the agricultural landscape to generate ecosystem services: An example from Sweden. *Ecological Economics* 29:269-291.

Bräuer, I., R. Mϋssner, K. Marsden, F. Oosterhuis, M. Rayment, C. Miller, and A. Dodoková. 2006. The use of market incentives to preserve biodiversity. *ECOLOGIC, 51p*.

Brosi, B. J, G. C Daily, and P. R Ehrlich. 2007. "Bee community shifts with landscape context in a tropical countryside." *Ecological Applications* 17:418–430.

Bryan, G. G, and L. B Best. 1991. Bird abundance and species richness in grassed waterways in Iowa rowcrop fields. *American Midland Naturalist* 126:90–102.

Camp, M. and L. B Best. 1993. Bird abundance and species richness in roadsides adjacent to Iowa rowcrop fields. *Wildlife Society Bulletin* 21:315–325.

Chan, K. M. A., M.R. Shaw, D. R. Cameron, E.C. Underwood, G.C. Daily. 2006. Conservation Planning for Ecosystem Services. *PloS Biology* 4(11):379.

Daily, G.C. (Ed.), 1997. *Nature's Services: Societal Dependence on Natural Ecosystems.* Island Press, Washington, DC. 392 pp.

Dale, V. H., and S. Polasky. 2007. Measures of the effects of agricultural practices on ecosystem services. *Ecological Economics* 64:286-296.

Daly, H. E. and J. Farley. 2003. *Ecological Economics: Principles and Applications.* Washington (DC): Island Press.

Decker, D. J., T. L. Brown and R. J. Guttierrez. 1980. Further insights into the multiple satisfactions approach for hunter management. *Wildlife Society Bulletin* 8:323-331.

Freemark, K. 1995. Assessing effects of agriculture on terrestrial wildlife: developing a hierarchical approach for the US EPA, *Landscape and Urban Planning* **31**:99–115.

Foley, J. A., R. DeFries, G. P. Asner, C. Barford, G. Bonan, S. R. Carpenter, F. S. Chapin, M. T. Coe, G. C. Daily, H. K. Gibbs, J. H. Helkowski, T. Holloway, E. A. Howard, C. J. Kucharik, C. Monfreda, J. A. Patz, C. Prentice, N. Ramankutty, and P. K. Snyder. 2005. GlobalConsequences of land use. *Science* 309:570-574.

Fussell, M. and S. A. Corbet. 1992. Flower usage by bumble-bees: a basis for forage plant management. *Journal of Applied Ecology*. 29(2):451-465.

Gallai, N., J. M. Salles, J. Settele and B. E. Vaissiere. 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological Economics* 68(3):810-821.

Goldman, R. L., B. H. Thompson, and G.C. Daily. 2007. Institutional incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. *Ecological Economics* 64:333-343.

Graefe, A., and A. Fedler. 1986. Situational and subjective determinants of satisfaction in marine recreational fishing. *Leisure Sci.* 8:275-296.

Hardin, G. 1968. The Tragedy of the Commons. *Science* 162:1243-1248.

Hammitt, W., J. Dulin, G. Wells. 1993. Determinants of quality wildlife viewing in Great Smoky Mountains National Park. *Wildlife Society Bulletin* 21(1):21-30.

Heal, G., G. C Daily, P. R Ehrlich, and J. Salzman. 2001. Protecting natural capital through ecosystem service districts. *Stanford Environmental Law Journal* 20:333-364.

Heikkila, T. and A. Gerlak. 2005. The formation of large-scale collaborative resource management institutions: clarifying the roles of stakeholders, science, and institutions. *The Policy Studies Journal* 33(4): 583-612.

Hodge, I., and S. McNally. 2000. Wetland restoration, collective action and the role of water management institutions. *Ecological Economics* 35:107–118.

Horrigan, L., R. S Lawrence, and P. Walker. 2002. How Sustainable Agriculture Can Address the Environmental and Human Health Harms of Industrial Agriculture. *Environmental Health Perspectives* 110:445.

Hoffman, J. 2008. Watershed shift: Collaboration and Employers in the New York City Catskill/Delaware Watershed from 1990-2003. *Ecological Economics* 68:141–161.

Holling, C. S., and G. K. Meffe. 1996. Command and control and the pathology of natural resource management. *Conservation Biology* 10(2):328-337.

Johansen, C. A. 1977. Pesticides and Pollinators. *Annual Review of Entomology*. 22:177-192.

Johnson, R. N. and G. D. Libecap. 1982. Contracting Problems and Regulation: The Case of the Fishery *The American Economic Review* 72(5):1005-1022

Kearns C., *D.* Inouye and N. Waser. *1998*. Endangered Mutualisms: The conservation of plant-pollinator interactions. *Annual Revue of Ecology and Systematics.* 29: 83-*112.*

Knoche, S. and F. Lupi. 2007. Valuing deer hunting ecosystem services from farm landscapes. *Ecological Economics* 64:313-320.

Kremen, C., N. M. Williams and R. W. Thorp. 2002. Crop Pollination from Native Bees at Risk from Agricultural, Intensification. *Proceedings of the National Academy of Sciences of the United States of America.* 99(26):16812-16816.

Kremen, C. 2005. Managing ecosystem services: what do we need to know about their ecology? *Ecology Letters* 8:468–479.

Kroeger, T., and F. Casey. 2007. An assessment of market-based approaches to providing ecosystem services on agricultural lands. *Ecological Economics* 64:321-332.

Lal, R. 2004a. Soil carbon sequestration to mitigate climate change. *Geoderma* 123:1–22.

Lal, R. 2004b. Soil carbon sequestration impacts on global climate change and food security. *Science* 304:1623.

Lal, R. 2007. Farming carbon. *Soil and Tillage Research* 96:1–5.

Lant, C. L, J. B. Ruhl, and S. E Kraft. 2008. The tragedy of ecosystem services. *BioScience* 58:969–974.

Livengood, K. 1983 Value of big game markets for hunting leases: the hedonic approach, *Land Economics* **59**(3):287–291.

Loehman, E. and A. Dinar. 1994. Cooperative Solution of Local Externality Problems: A Case of Mechanism Design Applied to Irrigation. *Journal of Environmental Economics and Management* 26:235-256.

Lubell, M., M. Schneider, J. T. Scholz, and M. Mete. 2002. Watershed partnerships and the emergence of collective action institutions. *American Journal of Political Science* 46(1): 148-163.

Lubell, M. 2004. Collaborative watershed management: A view from the grassroots. *Policy Studies Journal* 32(3):341-361.

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-Being: Current State and Trends, vol. 1*. IslandPress, Washington, DC.

Nabhan, G.P. and S.L. Buchmann. 1997. Pollination services: Biodiversity's direct link to world food stability. Pages 133-150 in G. Daily, editor. *Nature's Services: Societal Dependence on Natural Ecosystems.* Island Press, Washington, D.C.

OECD. 1999. Environmental Indicators for Agriculture, vol. 2, Issues and Design. In: Proceedings of the York Workshop. OECD Publications, Paris.

Olson, M. 1965. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, Mass.: Harvard University Press.

Onyx, J., and P. Bullen. 2000. Measuring social capital in five communities. *The Journal of Applied Behavioral Science* 36:23.

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.

Ostrom, E. 2001. Reformulating the Commons. In *Protecting the Commons: A Framework for Resource Management in the Americas*, ed. Joanna Burger, Elinor Ostrom, Richard B. Norgaard, David Policansky,and Bernard D. Goldstein. Washington, DC: Island Press, 17–41.

Ostrom, E. 2009. Analyzing Collective Action. Keynote papers presented in the Plenary Sessions of the 27th Conference of the International Association of Agricultural Economists. 16-22 August 2009, Beijing, China.

Parker, F., *S. Batra and V. Tepedino. 1987*. New pollinators for our crops. *Agric. Zool. Revue.* 2: 279-304.

Parkhurst, G., J. Shogren, C. Bastian, P. Kivi, J. Donner, and R. Smith. 2002. Agglomeration bonus: an incentive mechanism to reunite fragmented habitat for biodiversity conservation. *Ecological Economics* 41:305–328.

Parkhurst, G. and J. Shogren. 2007. Spatial incentives to coordinate contiguous habitat. *Ecological Economics* 64:344-355.

Pelosi, C., M. Goulard and G. Balent. 2010. The spatial scale mismatch between ecological processes and agricultural management: Do difficulties come from underlying theoretical frameworks? *Agriculture, Ecosystems & Environment*. 39 (4):455–462.

Pretty, J. 2003. Social Capital and the collective management of resources. *Science* 302:*1912-1914.*

Robertson, G. P, and S. M Swinton. 2005. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. *Frontiers in Ecology and the Environment* 3:38–46.

Salzman, J., B. H Thompson Jr, and G. C Daily. 2001. "Protecting ecosystem services: Science, economics, and law." *Stan. Envtl. LJ* 20:309.

Sandler, T. 1992. *Collective Action, Theory and Applications.* Ann Arbor: The University of Michigan Press.

Sanford, M. T. 1998. Pollination, the forgotten agricultural input. In: Ferguson. J. (Ed.) *Proceedings of theFlorida Agricultural conference and Trade Show*. University of Florida, Lakeland, Florida, pg. 45-47.

Sarker, A., H. Ross,and K.K. Shrestha. 2008. A common-pool resource approach for water quality management: An Australian case study. *Ecological Economics* 68:461-471.

Stallman, H. R, and L. B Best. 1996. Bird use of an experimental strip intercropping system in northeast Iowa. *The Journal of Wildlife Management* 60:354–362.

Stankey, G., R. Lucas and R. Ream. 1973. Relationship between hunting success and satisfaction. *Trans. North American Wildlife and Natural Resources Conference* 38:235-242.

Steffan-Dewenter, I., Ute Münzenberg, Christof Bürger, Carsten Thies, Teja Tscharntke. 2002. Scale-dependent effects of landscape context on three pollinator guilds. *Ecology* 83(5): 1421-1432.

Steffan-Dewenter, I. 2003. Importance of habitat area and landscape context for species richness of bees and wasps in fragmented orchard meadows. *Conservation Biology* 17:1036–1044.

Swinton, S. M., F. Lupi, G. P. Robertson and S. K. Hamilton. 2007. Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits. *Ecological Economics* 64:245-252.

Tillman, D., K.G. Cassman, P.A. Matson, R. Naylor and S. Polasky. 2002. Agricultural sustainability and intensive production practices. *Nature* 418:671–677.

Thomson, J. T, D. Feeny, and R. J Oakerson. 1986. "Institutional dynamics: the evolution and dissolution of common property resource management." Pp. 391–424 in *Proceedings of the Conference on Common Property Resource Management, April 21-26, 1985*.

Tscharntke, T., A. Klein, A. Kruess, I. Steffan-Dewenter & C. Thies. 2005. Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. *Ecology Letters* 8:857–874.

VanEngelsdorp D., R. Underwood, D. Caron, J. Hayes Jr. 2007. An estimate of managed colony losses in the winter of 2006–2007: a report commissioned by the Apiary Inspectors of America. *American Bee Journal* 147: 599–603.

VanEngelsdorp, D. , J. Evans, C. Saegerman, C. Mullin, E. Haubruge, B. Nguyen, M. Frazier, J. Frazier, D. Cox-Foster, Y.Chen, R. Underwood, D. Tarpy and J. Pettis. 2009. Colony collapse disorder: a descriptive study. *PLoS One* 4:e6481.

West, T. and W. Post. 2002. Soil organic carbon sequestration rates by tillage and crop rotation: a global data analyses, *Soil Sci. Soc. Am. J.* **66:**1930–1946.

White, T. A, and C. F Runge. 1994. "Common property and collective action: Lessons from cooperative watershed management in Haiti." *Economic Development and Cultural Change* 43:1–41.

Wossink, A. and S. M. Swinton. 2007. Jointness in production and farmers' willingness to supply non-marketed ecosystem services. *Ecological Economics* 64:297-304.

Zhang, W., T. H. Ricketts, C. Kremen, K. Carney, and S. M Swinton. 2007. Ecosystem services and dis-services to agriculture. *Ecological Economics* 64:253–260.

CHAPTER THREE

Determinants Affecting Farmers' Willingness to Cooperate to Control Pests

Abstract: Although natural pest control is an important ecosystem service provided by agriculture, it is rapidly declining in the United States. Farmers may be able to increase the provision of natural pest control by working together in pest control cooperatives. However, it is unknown whether US farmers are willing to cooperate to control pests, what type of cooperation they are willing to consider, and what determinants may affect their willingness to cooperate. In this study, we survey 229 Missouri crop farmers to explore farmers' willingness to cooperate to control pests. We find that 91% of farmers say they are willing to cooperate in at least one pest control effort, and that simple, local cooperative efforts may be more popular than formal, county-wide efforts. In addition, the determinants that affect cooperative pest control closely follow those predicted by the collective action, agricultural adoption, and ecosystem management literatures. Farmers who believe they will receive a benefit from cooperation, have farms similar to their neighbors', are active members of a community organization, have positive contact with agricultural extension agents, and are concerned about the affect pesticides may have on the environment are more willing to cooperate to control pests than farmers who do not share these characteristics. This study provides valuable insights into the conditions that may foster cooperation between farmers in the provision of an ecosystem service. Plus, it may help facilitate the formation of pest control cooperatives in the United States.

Key Words: natural pest control, ecosystem services, cooperative pest control, collective action, agriculture, integrated pest control, willingness to cooperate

1. Introduction: Pest control is an important ecosystem service (ES) provided by agricultural ecosystems. Often called natural pest control or ecological pest control, this ES involves the suppression of pests by the natural populations of animals, plants, fungi, and pathogens that live in the ecosystem, plus the ecosystem's geophysical characteristics, such as soil type and climate (Zhang et al., 2007; Naylor and Erlich, 1997). Natural pest control maintains the stability and resilience of agricultural ecosystems, while providing direct and indirect environmental, health and economic benefits to farmers and society (Zhang et al., 2007; Bianchi et al., 2006; Östam et al., 2003; Naylor and Erlich, 1997). Despite its importance, natural pest control's quantity and quality are rapidly declining in agricultural ecosystems in North America due to the intensification of agriculture (Landis et al., 2008; Bianchi et al., 2006; Whilby and Thomas, 2002; Matson et al., 1997).

Many scholars claim that the reduction of natural pest control services, coupled with the continued preference of most North American farmers to use chemical-intensive pest control methods, may jeopardize the ability of agricultural ecosystems to sustain production of food, fuel and fiber (e.g. Wilson and Tisdell, 2001). Although chemical pesticides may provide effective pest control in the short-run, often serving as a substitute for natural pest control, pesticides are not robust enough for the long-run control of pests because of problems with pesticide resistance, reduction of natural pest control services, reduction of pollinating insect populations, decreased water quality and concerns about human health (Crowder et al., 2010; Cumming and Spiesman, 2006; Kremen, 2005; Tillman et al., 2002; Nabhan and Buchmann, 1997; Naylor and Erlich, 1997). Many scholars argue that a more robust and less costly system of pest control must include the enhancement of natural pest control processes in addition to chemical and cultural pest control (e.g. Cumming and Spiesman, 2006; Klingauf, 1988).

One way farmers may be able to increase the provision of natural pest control in agricultural ecosystems is by working together in pest control cooperatives to collectively manage their land for improved natural pest control. Stallman (2011) identifies the ES pest control as highly suited for collective management in agricultural ecosystems. In addition, Ravnborg (2004) claims that in situations where technical solutions are not enough, farmers must work together to provide successful pest management. In fact, many scholars agree that most ES, including natural pest control, should be managed at the landscape level and include a coordinated effort between landowners to be effective (e.g. Cong et al., 2014a; Tscharntke et al., 2005; Goldman et al., 2007). Little is known, however, about farmers' attitudes, perceptions and willingness to cooperate to control pests.

Previous studies document that some North American farmers are willing to cooperate to control pests, including apple growers in New York and cotton farmers in Arizona (Tette et al, 1987; Ayer, 1997). No study, however, has evaluated what determinants influence farmers' willingness to cooperate to control pests. In addition, no study has attempted to explore or synthesize various literatures to predict these determinants. For example, the collective action literature attempts to explain a person's willingness to cooperate with others to achieve a common goal. The agricultural adoption literature attempts to explain a farmer's willingness to adopt new technologies or management practices, and the ecosystem management literature attempts to explain a landowner's willingness to comply to landscape level management decisions designed to enhance a natural resource. All or none of these diverse literatures may provide insight into farmers' willingness to cooperate to control pests.

Are Midwestern US farmers willing to cooperate to control pests on their farms? If so, what types of cooperation are they willing to consider, what determinants affect their willingness to cooperate, and do those determinants follow the predictions of collective action theory, the agricultural adoption literature and the ecosystem management literature? In this study, we explore the answers to these questions by using a survey of 229 Missouri agricultural producers. We find that most Missouri crop farmers say they are willing to cooperate to control pests and that simple, local cooperative efforts may be more popular than formal, county-wide efforts. In addition, we find that farmers who believe they will receive a benefit from cooperation, have farms similar to their neighbors' farms, are active members of a community organization, trust agricultural extension agents for pest control information, and are concerned about the affect pesticides may have on the environment are more willing to cooperate than farmers who do not share these characteristics.

This study is important because it provides valuable insights into the conditions that may foster cooperation between farmers in the provision of the ES pest control. Plus, this study synthesizes information from three diverse literature bases and confirms that the determinants that affect cooperative pest control efforts follow those predicted by the collective action literature, the agricultural adoption literature and the ecosystem management literature.

2. Background Literature:

2.1 Why Cooperate?: Many scholars believe that most ES, including natural pest control, must be managed at the landscape level and include a coordinated effort between landowners to insure effective provision (e.g. Goldman et al., 2007; Tscharntke et al., 2005). In addition, Cong et al. (2014a) found that the landscape level management of ES provided by mobile organisms, such as insect pollinators, is more profitable for all farmers in the landscape than farm-level management. Proponents of the cooperative provision of ES often point to the spatial scale-mismatch between ES and agriculture as justification for the necessity of cooperative provision (e.g. Goldman et al., 2007). In other words, the spatial scale of management in agricultural ecosystems (e.g. a 500 acre farm) often does not match the spatial scale of ecosystem processes necessary to provide an ES (e.g. a tri-county watershed), making cooperation necessary (Pelosi et al., 2010; Cumming et al., 2006). For the ES, pest control, the scale needed for effective management may vary depending on the pest predator or parasitoid species of interest (Schmidt et al., 2005; Roland and Taylor, 1997). For example, spatial scales from 1 - 3 km of a focal point tend to offer the most explanatory power for population characteristics of various species of spiders, although shorter and larger distances also can affect species richness, abundance and diversity (Schmidt et al., 2008; Schmidt and Tscharntke, 2005; Gardiner et al., 2009).

Currently, most proposed natural pest control solutions involve individual farmers applying strategies and techniques to their individual farms to reduce pesticide use and to facilitate enhanced natural pest control on their farms (Pickett and Bugg, 1998; Landis et al., 2000). Disease transmission and pest insect movements, however, involve landscape-level processes, as do the natural pest control processes that keep pest pathogens and insects in check (Östam et al., 2003; Bianchi et al., 2006; Tscharntke et al., 2007). For example, the species pool in the surrounding landscape, the structural complexity of the landscape, the connectivity of breeding and rest habitats, and the distance of the crop from natural habitat are important for the conservation of pest enemy diversity and to maintain pest enemy populations large enough to effectively control pests (Bianchi et al., 2006; Tscharntke et al., 2007).

<u>2.2 Cooperative Pest Control</u>: Although little is known about farmers' attitudes, perceptions and willingness to cooperate to control pests, a few studies have documented

US farmers' participation in pest control cooperatives and districts, including cotton growers in Arizona and apple growers in New York (Ayer, 1997; Tette et al., 1987). In each case, the cooperative's main function was to pool its members' financial resources to hire a pest control manager who facilitated the application of integrated pest management (IPM) techniques by individual farmers on their individual farms (Tette et al., 1987; Ayer, 1997). IPM is a pest management system that requires monitoring pest populations and taking actions, such as pesticide application or cultural control, only when a certain threshold is reached (Flint, 2012; Dent, 1995). IPM was designed to consider multiple pest management goals, including economic, social, and environmental goals (Dent, 1995). Plus, it has been practiced cooperatively in some areas of the world (e.g. Stemerding et al., 2002; Pontius et al., 2002), and is the likely path that cooperative or landscape-level pest management will take (Zalucki et al., 2009). As it is currently practiced in North America, however, IPM falls short of its potential to provide an enhanced quality and quantity of natural pest control (Cumming and Spiesman, 2006).

Cumming and Spiesman (2006) offer insights about how IPM could be re-envisioned as a greater cooperative effort between farmers to provide enhanced regional pest control, including enhanced natural pest control. They argue that the greatest limitation of IPM the way it is currently practiced is that it does not effectively integrate landscape-level ecosystem processes into its design. To be truly effective, they argue IPM must be practiced on a regional scale where landowners 1) cooperate in scouting for pest outbreaks, 2) coordinate the amount, spacing and landscape-configuration of pest predator breeding and rest habitat within the region, 3) coordinate crop rotation on a regional level 4) coordinate the number of acres and the landscape configuration of acres planted to a single crop 5) coordinate the minimal use of least-toxic pesticides and 6) coordinate the release of biological controls that will enhance the natural pest control processes already operating in the region (Cumming and Spiesman, 2006). By integrating these cooperative practices into IPM, Cumming and Spiesman (2006) argue that a more robust form of pest management could be achieved, leading to a greater ability of agricultural ecosystems to sustain long-term production of food, fuel, and fiber.

Some agricultural extension programs in the United States incorporate an element of cooperative pest scouting into their program. For example, the University of Missouri's IPM program offers farmers the opportunity to sign up to receive pest alerts, where farmers are informed by email when an agricultural extension agent has discovered a pest outbreak within their county (MU Plant Sciences, 2012). In addition, some pest control districts in Arizona make collective management decisions that all members are encouraged to abide by, such as setting pest damage thresholds for pesticide application and by using a board of growers to make pesticide application recommendations (Ayer, 1997). Few other cooperative efforts to provide enhanced natural pest control in agricultural ecosystems exist in the United States, however, and no known cooperative effort incorporates all of the elements from Cumming and Spiesman (2006). In fact, the apple growers' pest management cooperative in New York doesn't incorporate any of these cooperative pest management elements into its design (Tette et al., 1987).

3. Conceptual Framework:

In this study we explore Missouri crop farmers' willingness to cooperate (WTC) in various forms of cooperative pest control and the determinants that influence their willingness to cooperate. Conceptually, our model can be expressed as farmers' WTC is a function of a set of predictor variables, farmer characteristics and farm characteristics.

Ours is an exploratory study because very little is known about farmers' willingness to cooperate to control pests. Therefore, we build our model by using theory from three bodies of literature that may provide insight into a farmer's willingness to cooperate. First, we chose predictor variables from the collective action literature, which attempts to explain a person's willingness to participate in a group or a person's willingness to cooperate with others to achieve a common goal, such as improved pest control or reduced pesticide use. Second, we explored the agricultural adoption literature, which attempts to explain a farmer's willingness to adopt new technologies or new management practices, such as cooperatively scouting fields for pests. Finally, we considered the ecosystem management literature, which attempts to explain a landowner's willingness to participate in programs that require compliance to landscape level management decisions that are designed to enhance a natural resource, such as the coordinated placement of pest predator breeding habitat within a region. From these three bodies of literature, we identified seven predictor variables for our model.

Collective action theory states that people are more willing to join a group or more willing to cooperate to solve a mutual problem if the following are true: 1) they perceive that they will receive a positive benefit from their cooperation, 2) group members have similar backgrounds and goals, 3) they feel they can trust other members of the group and 4) they have strong social connections and ties in their community or in other groups (Ostrom, 1990, 2009; Kahan, 2003; Pretty, 2003).

Previous studies have found that a farmer's tendency to join traditional agricultural cooperatives, such as marketing cooperatives, closely follows collective action theory (e.g. Staatz, 1987; Cook, 1995). Collective action theory also applies to the collective management of natural resources by the resource users, such as ranchers who collectively manage a pasture for their sheep (e.g. Ostrom, 1990). Therefore, we hypothesize that farmers' willingness to cooperate to control pests will closely follow collective action theory. Specifically, we hypothesize:

H1: Farmers who perceive that they can achieve more effective pest control by working with their neighbors or by rotating crops on a county-wide scale will be more willing to cooperate in these cooperative pest control efforts than farmers who do not believe they can achieve more effective pest control by working with their neighbors or by rotating crops on a county-wide scale.

H2: Farmers who perceive that their farm and farm operations are similar to their neighbors' farms and farm operations will be more willing to cooperate to control pests than farmers who perceive that their farm and farm operations are different than their neighbors'.

H3: Farmers who believe that their neighbors or other farmers in their community are usually trustworthy will be more willing to cooperate to control pests than farmers who believe that their neighbors or other farmers in their community are sometimes trustworthy or rarely trustworthy.

H4: Farmers who are active participants in a community organization will be more willing to cooperate to control pests than farmers who are not active members in a community organization.

In addition to the collective action literature, we also explored the agricultural adoption literature and the ecosystem management literature to find predictor variables for our model. Adoption studies attempt to explain the determinants that influence an agricultural producer's willingness to adopt new technologies or new management practices (Sunding and Zilberman, 2001). For most farmers, cooperating with other farmers to control pests on their combined land is a new management practice. Additionally, the specific techniques that farmers must coordinate within a pest control cooperative, such as crop rotations, may also be a new practice. Thus, participation in a cooperative pest control effort, such as sharing scouting reports with a regional pest coordinator, requires some farmers to adopt a management practice with one new dimension (cooperation), while it requires other farmers to adopt a management practice with two new dimensions (scouting fields and cooperation). The agricultural adoption literature states that experience or familiarity with a management practice increases the likelihood that the practice will be adopted (e.g. Rogers, 2003). Thus, we hypothesize:

H5: Farmers who currently scout their fields for pests or rotate their crops will be more willing to participate in cooperative pest control efforts that involve these IPM techniques than farmers who do not currently scout their fields or rotate their crops.

Although agricultural adoption studies encompass a large body of literature, often with contradictory findings, three factors besides familiarity seem to have a consistent effect on adoption rates: 1) profitability or a perceived benefit from the innovation 2) the ability to gather information about the innovation, either through social networking or through exposure to agricultural extension agents, and 3) environmental attitudes and awareness (Gedikoglu and McCann, 2010; Prokopy et al., 2008). Ecosystem management studies have also found that landowners' willingness to participate in government agency-led ecosystem management programs is influenced by three factors similar to those that influence agricultural adoption decisions, namely 1) the profitability or economic feasibility of the required management practices, including the ability to participate in cost-share programs 2) trust in the leading agency (entrepreneur) and other participants in the program, including trust in agricultural extension agents who help farmers to implement the required management practices and 3) environmental awareness or concern (Raedeke et al., 2001; Jacobson, 2002; Wondolleck and Yaffee, 2000).

Farmers who are willing to cooperate to control pests must be willing to adopt new ways of managing their land. Plus, they must voluntarily chose to conform to management practices designed to affect landscape level processes in order to create a landscape-level benefit, similar to farmers who chose to participate in landscape level ecosystem management programs. Therefore, we hypothesize that a farmer's willingness to cooperate will closely follow theory from the agricultural adoption literature and from the ecosystem management literature. Specifically, these two literature bases add support to H1, H3, and H4 above. In addition, we hypothesize:

H6: Farmers who rely on agricultural extension agents for pest control information will be more willing to cooperate to control pests than farmers who do not rely on agricultural extension agents for pest control information.

H7: Farmers who are highly concerned about the effect pesticides have on certain environmental factors (such as pollinator populations, streams and lakes, wildlife, pest predator populations, and rural drinking supplies) will be more willing to cooperate to control pests than farmers who are only somewhat concerned or are unconcerned about the affect pesticides have on these factors.

Finally, the collective action literature, the agricultural adoption literature, and the ecosystem management literature contain numerous studies where farmer or farm characteristics influenced a farmer's willingness to join a group, to adopt a new innovation, or to participate in an ecosystem management program. Examples of these farmer and farm characteristics include farm size, farmer's age, farmer's education level, farmer's sex, total farm sales, off-farm income, land tenure, and the crop grown. In some studies these control variables had a positive effect on participation or adoption, but in other studies they had a negative effect or no effect. Because of these inconsistencies, and because of the large number of potential control variables, we do not make specific hypothesis for all of the farm or farmers characteristics we consider in this study.

4. Methods

We surveyed a random sample of 1,000 agricultural producers from Missouri with farm sales greater than $10,000 in 2011. The random sample was drawn by the National

Agricultural Statistical Service (NASS) from a sample population that included all producers in Missouri who grew crops, such as corn and vegetables, except for the following exclusions. We did not include landowners who did not farm the land themselves or farmers who produced only livestock plus hay for that livestock. We disproportionately sampled fruit and vegetable farmers to make sure they were adequately represented in the sample. Additionally, we excluded farmers who lived in counties with low crop production. Instead, we only included those producers who lived in counties with moderate to high crop production where 1) farmers may have experienced increased pest problems due to increased agricultural intensity and 2) farmers are likely to have other producers with whom to cooperate, both for local and county-wide pest control efforts. From 2007 – 2011, most Missouri counties either had < 5,000 acres in production or > 10,000 acres in production per year for both corn and soybeans. We chose to define high to moderate crop production as counties that had > 10,000 acres in production per year for both corn and soybeans for at least 3 out of the 4 years prior to the study. This gave us a total of 77 included counties and 37 excluded counties, which were predominantly urban or Ozark forest. The excluded counties also recorded low acres in production for wheat, cotton and sorghum, often so low that total acres in production for these crops wasn't reported for the county.

We sent our first wave of surveys with a request for participation to our random sample of 1000 agricultural producers in early November of 2012. A second letter and survey were sent to all 1000 producers four weeks later with a second request for participation. We had a return rate of 30%, which is not unusual for Midwestern farmers (i.e. Hendrickson and James, 2005). Of the 300 returned surveys, 229 were useable for our study. Our pool of respondents produced all major crop types grown in Missouri, including corn, soybeans, wheat, hay, cotton, tobacco, sorghum, vegetables and fruit (especially melons and grapes). Our respondents' average age was 59.1 years, which is slightly higher than the average age of Missouri agricultural producers in 2012 (MO average =58.3 years). Our respondents were 96% male, which is also higher than the percent of male principle farm operators in Missouri in 2012 (89%). In addition, the median farm sales category for our respondents was the $50,000 - $100,000 annual sales category which corresponds to the average farm sales for all Missouri agricultural producers in 2012 ($95,680). Thus, our respondents are likely a representative sample of Missouri crop farmers, with the exception that we had fewer female respondents than expected. This may be because we disproportionately sampled fruit and vegetable farmers, because we excluded producers from counties with low crop production, because we excluded farmers whose farm income was less than $10,000, or because we excluded farmers who produced only livestock.

The survey instrument was designed to collect information about the producers' farm operations, their attitudes and perceptions about pests and pesticide use, their perceptions about landscape processes that might make cooperation desirable, their willingness to cooperate to control pests, their trust in others and their community involvement. When possible, these questions were garnered from the literature and reflect standard questions that researchers have used to measure demographic information, general trust, relational trust, community involvement etc. (e.g. Phan, 2008; Lochner et al., 1999). Questions regarding WTC were included at the end of the second section. The WTC questions included general questions about the farmer's willingness to cooperate with a neighbor to manage pests on their combined land or the farmer's willingness to learn more about cooperative pest control. The survey instrument also included more specific WTC questions that reflected 1) current cooperative opportunities for Missouri farmers in the University of Missouri Agricultural Extension IPM Program (MU Plant Sciences, 2012), 2) cooperative pest control efforts that have been successful in other states and countries (e.g. Ayer, 1997) and 3) potentially desirable cooperative efforts as outlined by Cumming and Spiesman (2006). These specific questions explored the farmers' willingness to participate in such activities as cooperative scouting, coordinated pesticide application, coordinated release of biological pest controls, coordinated crop rotations on a county-wide scale, coordinated crop diversity initiatives and coordinated placement of pest predator habitat. All regional efforts were defined as county-wide efforts on the survey (average MO county-size = 598 square miles)., so that the respondents had a familiar and common frame of reference for what was meant by regional, not because we believe a political border such as a county is the most ecologically important way to delineate cooperative efforts. Farmers were provided with a list of these voluntary cooperative pest control activities and were asked to what degree (based on a Likert scale from 1 - 5) they were willing (=1) or unwilling (=5) to participate in the activity.

Definitions and summary statistics for our WTC variables as well as our predictor and control variables are given in Table 3.1. Our dependent variables are binary variables constructed from individual questions concerning a producer’s willingness to cooperate in some aspect of cooperative pest control. Our predictor and control variables are binary, categorical or continuous variables, constructed from individual survey questions or from a series of related questions (Table 3.1). Specifically, the predictor variables for each model in our analysis is a set of seven variables that correspond with our seven hypotheses: H1) *Perceived Benefit 1* or *Perceived Benefit 2,* H2) *Similarity,* H3) *Trusts Neighbors* or *Trusts Community Farmers, H*4) *Social Capital, H*5) *Scouts Fields* or *Rotates Crops, H*6) *Extension Agent* and H7) *Environmental Concern.* The variables for H5, *Scouts Fields* or *Rotates Crops,* were designed to differentiate between farmers for which a cooperative scouting effort or an effort to coordinate crop rotations includes one new dimension (cooperation) and those for which it includes two (cooperation and scouting fields or rotating crops). The *Extension Agent* variable was designed to be a proxy for positive exposure to agricultural extension agents, while the *Environmental Concern* variable was designed to be a proxy for environmental awareness and concern, especially in regards to concern about the use of pesticides in agriculture.

Our control variables represent farm and farmer characteristics that are often important in agricultural adoption studies, including IPM adoption studies (Fernandez-Cornejo et al., 1994; Gedikoglu and McCann, 2010; Prokopy et al, 2008), and were identified as potentially meaningful for our study after preliminary analysis using cross tabulations, binary regression models and ordinal regression models. We chose to include two farm characteristic variables in our model, *Farm Sales* and *Percent of Household Income from Farming*, and two farmer characteristics, *Farmer's Age* and *High School Diploma*, all four of which we expect to have positive effect on WTC (Table 3.1). We chose to use high school diploma as the cut-off for our dichotomous education variable, instead of the more common college degree cut-off, because preliminary analysis showed that the high school diploma cut-off may be more meaningful for our study. Of all our

Table 3.1. Variable description and summary statistics

Variable	Description	Mean	S.D.
Dependent			
Work with neighbors	Binary variable equal to 1 if respondent indicated a willingness to participate in the cooperative effort (response of 1 or 2 on a 5-point scale): "Work with my closest neighbors to manage pests on our land," 0 otherwise	0.74	0.44
Cooperative scouting	Binary variable equal to 1 if respondent indicated a willingness to participate in the cooperative effort (response of 1 or 2 on a 5-point scale): "Cooperate with my neighbors in scouting for pest outbreaks," 0 otherwise	0.69	0.46
County-wide crop rotation	Binary variable equal to 1 if respondent indicated a willingness to participate in the cooperative effort (response of 1 or 2 on a 5-point scale): "Participate in a county-wide effort to rotate crops," 0 otherwise	0.71	0.45
Predictors			
Perceived benefit 1	Binary variable equal to 1 if respondent agreed with this statement (response of a 1 or 2 on a 5-point scale): "If my neighbors and I worked together, we could manage pests more effectively," 0 otherwise	0.68	0.47
Perceived benefit 2	Binary variable equal to 1 if respondent agreed with this statement (response of a 1 or 2 on a 5-point scale): "It would be easier to control pests by crop rotations if most farmers in my county would coordinate their crop rotations," 0 otherwise	0.40	0.49
Trusts neighbor	Binary variable equal to 1 if respondent indicated that his neighbors are usually trustworthy, 0 if respondent indicated that his neighbors were sometimes trustworthy or rarely trustworthy.	0.79	0.41
Trusts farmers	Binary variable equal to 1 if respondent indicated that farmers in his or her community are usually trustworthy, 0 if respondent indicated that farmers in his or her community were sometimes trustworthy or rarely trustworthy	0.72	0.45
Similarity	Binary variable equal to 1 if respondent indicated similarity after this statement (1 or 2 on a 5-point scale): "Think of your nearest 4-5 neighbors. How different or similar to your farm are most of your neighbor's farms or properties," 0 otherwise	0.68	0.47
Social capital	Binary variable equal to 1 if respondent claimed to be an active member of at least one community organization, 0 if the respondent claimed to be an inactive member or nonmember of all community organizations	0.82	0.39
Scouts fields	Binary variable equal to 1 if respondent claimed to have scouted fields for pests within the last three years, 0 otherwise	0.74	0.44
Rotates crops	Binary variable equal to 1 if respondent claimed to have rotated crops within the last three years, 0 otherwise	0.80	0.40
Extension agent	Binary variable equal to 1 if respondent relies on agricultural extension agents for pesticide information; 0 otherwise	0.44	0.50
Environment	Count variable from 0-5, indicating number of environmental factors where respondent was highly concerned about pesticide affect, including streams and lakes, bees and other pollinators, pest predator insects, wildlife, and rural drinking supplies	2.61	1.98
Controls			
Age	Continuous variable indicating respondent's age	59.11	12.37
High school diploma	Binary variable equal to 1 if the respondent graduated from high school or received a G.E.D.; 0 otherwise	0.93	0.50

% Income from farming	Binary variable equal to 1 if 75 -100% of the respondent's household income came from farming; 0 otherwise	0.47	0.50
Farm sales	Categorical variable representing total farm sales from 2011 where 1 = \$10,000 - \$50,000, 2= \$50,000 - \$100,000, 3= \$100,000 - \$250,000 and 4 = over \$250,000		

Valid N (listwise) = 204

predictor and control variables, only two (*Trusts Neighbors* and *Trusts Community Farmers*) show a significant and moderately strong correlation (Pearson's r = 0.575**). However, these two variables are never included in the same model in our analysis. All other variables in our study showed weak or moderately weak correlations (Pearson's r < 0.5).

To empirically test what determinants may influence a farmer's willingness to cooperate to control pests, we specify the following econometric model:

$$WTC = \alpha + X'\beta + Z'\gamma + \varepsilon$$

where WTC is a vector of farmers' willingness to cooperate to control pests, α is the intercept, X is a vector of predictor variables, β is a vector of parameters to be estimated, Z is a vector of control variables that represent farm and farmer characteristics, γ is vector of parameters to be estimated and ε is the error term. Because our dependent variable (WTC) is binary and X and Z are comprised of binary, continuous and categorical variables (Table 3.1), we estimate this equation by using a binary logistic regression model.

5. Results

Figure 3.1 shows the percent of Missouri crop farmers' who indicated a willingness to cooperate in various voluntary, cooperative pest control efforts. Of 226

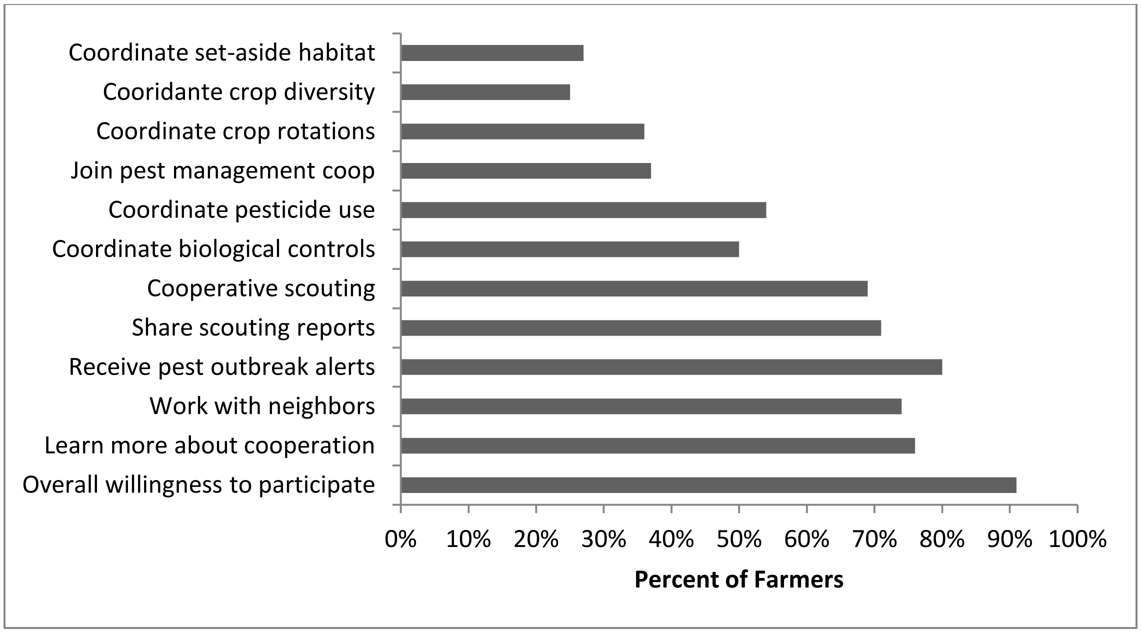

Figure 3.1. Percent of Missouri crop farmers who indicated a willingness to participate in various voluntary cooperative pest control efforts. n=226

respondents, 91% indicated they are very willing or somewhat willing to cooperate in at least one cooperative pest control effort. Seventy-six percent of Missouri farmers said they are willing to learn more about cooperative pest control, while 74% said they are willing to work with their closest neighbors to control pests on their combined land. Potential cooperative efforts that involve the scouting of agricultural land for pests or pest outbreaks are also popular among Missouri crop farmers. Eighty percent of respondents indicated they are willing to sign up to receive pest outbreak alerts from a regional pest coordinator, 71% are willing to share their own scouting reports with a regional pest coordinator, and 69% are willing to participate in cooperative scouting efforts with their neighbors.

Slightly less popular cooperative efforts include coordinating the timing and amount of pesticides used with the farmers' neighbors or with other local farms (54%

WTC) and coordinating the release of biological pest controls with the farmers' neighbors or other local farmers to enhance the natural populations of insect pest predators (50% WTC). Finally, the least popular cooperative pest control efforts include more formal, larger scale efforts such as joining a county-wide pest control cooperative (34% WTC), participating in a county-wide effort to coordinate crop rotations (36% WTC), participating in a county-wide effort to coordinate the amount and placement of set aside land for pest predator and pollinating insects (27% WTC) and participating in a county-wide effort to coordinate crop diversity and the number of acres planted to each crop type (25% WTC).

We find that most Missouri farmers believe they could more effectively control pests if they worked with their neighbors instead of working alone (68%). Most farmers also believe that natural pest control processes, such as predation by pest predators, are important for agriculture (80%), and over half (57%) either don't use pesticides or want to decrease their pesticide use.

Two-way cross tabulations analysis shows that potential participants (n= 205) and non-participants (n=21) are not significantly different from each other in regards to most farm and farmer characteristics, including crops grown (corn, soybean, cotton, wheat, hay, tobacco and fruit), farm sales, acres farmed (farm size), percent of income from farming, percent of farm land owned (tenure), current use or interest in IPM, number of agricultural products produced, livestock production in addition to crop production, perception of pest problems, source of pest control information (with the exception of agricultural extension agents, which are included in our model), or the farmer’s age. Vegetables farmers are more likely to be potential cooperators than farmers who did not grow vegetables (X^2=4.34, 1 df, p=0.036). In addition, all female respondents (n=8) indicated a willingness to cooperate to control pests.

In order to evaluate what determinants may influence a farmer's willingness to cooperate to control pests, we perform a variety of binary logistic regression analyses in which the dependent variables are willingness to cooperate in one of three voluntary cooperative pest control efforts: work with neighbors to control pests (Table 3.2), cooperative scouting for pests (Table 3.3) and coordinating crop rotations on a county-wide scale (average MO county-size = 598 square miles) (Table 3.4). We chose these three WTC variables because they represent diverse cooperative efforts with varying complexity and popularity among Missouri farmers (Figure 3.1). Specifically, we chose one general, popular effort (work with neighbors), one specific, popular effort (cooperative scouting) and one specific, unpopular effort (coordinate crop rotations) for our WTC variables. We could not include a general, unpopular effort in our analysis because both general efforts in our study were popular among Missouri farmers (Figure 3.1).

In order to show the robustness of our results, we start each analysis with a model that includes only our predictor variables. We build our analysis with models that include either farm characteristics or farmer characteristics, and end with a model that includes all of the predictor variables and controls for each analysis (Tables 3.2 - 3.4). We find that the determinants that affect willingness to cooperate to control pests follow those predicted by collective action theory, the agricultural adoption literature and the ecosystem management literature. Specifically, we find that farmers who believe they can achieve more effective pest control by working with their neighbors or by coordinating

Table 3.2

Logit analysis of the determinants affecting farmers' willingness to work with neighbors to control pests

Variable	Expected Sign	Model 1	Model 2	Model 3	Model 4
Trusts Neighbors	+	0.23 (0.42)	0.32 (0.46)	0.25 (0.43)	0.332 (0.481)
Perceived Benefit	+	1.13*** (0.37)	1.15*** (0.40)	1.17*** (0.39)	1.204*** (0.43)
Similarity to Neighbor's Farms	+	0.94*** (0.37)	0.93** (0.40)	0.87** (0.38)	0.91** (0.42)
Environmental Concern	+	0.24*** (0.09)	0.32*** (0.11)	0.26*** (0.10)	0.34** (0.12)
Social Capital	+	1.09*** (0.44)	1.52*** (0.50)	1.25*** (0.46)	1.86*** (0.540)
Extension Agent Contact	+	0.84** (0.38)	0.91** (0.42)	0.82** (0.39)	0.94** (0.44)
Scouts Fields	+	0.52 (0.40)	0.31 (049)	0.47 (0.41)	0.25 (0.51)
Farm Sales ($10,000 - $50,000)			0.25 (0.65)		0.56 (0.68)
Farm Sales ($51,000 - $100,000)			0.97 (068)		1.26* (0.72)
Farm Sales ($101,000 - $250,000)			-0.62 (0.55)		-0.40 (0.56)
Percent Income From Farming >75%	+		1.27*** (0.47)		1.50*** (0.49)
High School Diploma or Above	+			1.07 (0.66)	1.16 (0.76)
Farmer's Age	_			-0.01 (0.02)	-0.02 (0.02)
Intercept		-2.59 (0.70)	-3.72 (0.97)	-3.13 (1.33)	-4.29 (1.62)
Psuedo - R2		0.28	0.37	0.30	0.41
-2 Log Likelihood		195.60	170.72	190.17	163.56
Chi-Square (df) for variables in the model		45.31 (7)***	59.94 (11)***	48.27 (9)***	65.24 (13)***
% Correctly Predicted		78.5%	82.4%	78.5%	82.1%
Number of Observations		209	199	205	196

Note: Standard Errors are in parentheses. %. The excluded Farm Sales Category is Farm Sales > $250,000.
* Significant at 10%, ** Significant at 5%, ***Significant at 1%

Table 3.3

Logit analysis of the determinants affecting farmers' willingness to participate in cooperative scouting with neighboring farmers

Variable	Expected Sign	Model 1	Model 2	Model 3	Model 4
Trusts Neighbors	+	0.11 (0.41)	0.26 (0.43)	0.15 (0.42)	0.26 (0.44)
Perceived Benefit	+	0.91*** (0.35)	0.812** (0.37)	0.95*** (0.37)	0.83* (0.39)
Similarity to Neighbor's Farms	+	0.43 (0.35)	0.41 (0.37)	0.44 (0.36)	0.44 (0.37)
Environmental Concern	+	0.17*** (0.09)	0.28*** (0.10)	0.17* (0.09)	0.27*** (0.11)
Social Capital	+	1.03*** (0.43)	1.12*** (0.45)	1.14*** (0.44)	1.30*** (0.47)
Extension Agent Contact	+	1.12*** (0.35)	1.17*** (0.38)	1.03*** (0.37)	1.11*** (0.47)
Scouts Fields	+	0.54 (0.41)	0.21 (0.44)	0.57 (0.39)	0.24 (0.45)
Farm Sales (\$10,000 - \$50,000)			-0.67 (0.60)		-0.49 (0.61)
Farm Sales (\$51,000 - \$100,000)			-0.48 (0.58)		-0.18 (0.60)
Farm Sales (\$101,000 - \$250,000)			-0.65 (0.52)		-0.50 (0.52)
Percent Income From Farming >75%	+		0.47 (0.41)		0.57 (0.42)
High School Diploma or Above	+			0.42 (0.67)	0.25 (0.70)
Farmer's Age	_			-0.01 (0.02)	-0.02 (0.02)
Intercept		-2.22 (0.66)	-2.15 (0.84)	-1.83 (1.24)	-1.80 (1.40)
Psuedo - R2		0.25	0.29	0.27	0.30
-2 Log Likelihood		216.12	199.93	209.95	195.32
Chi-Square (df) for variables in the model		41.38(7)***	46.96 (11)***	42.99 (9)***	47.74 (13)***
% WTP Correctly Predicted		75.6%	74.9%	76.1%	76.0%
# of Observations		209	199	205	196

Note: Standard Errors are in parentheses. The excluded Farm Sales Category is Farm Sales > \$250,000.
* Significant at 10%, ** Significant at 5%, ***Significant at 1%

Table 3.4

Logit analysis of the determinants affecting farmers' willingness to participate in a county-wide effort to coordinate crop rotations.

Variable	Expected Sign	Model 1	Model 2	Model 3	Model 4
Trusts other Farmers in Community	+	0.03 (0.36)	-0.06 (0.37)	0.13 (0.38)	0.10 (0.38)
Perceived Benefit 2	+	1.35*** (0.32)	1.28*** (0.33)	1.49*** (0.34)	1.45*** (0.35)
Similarity to Neighbor's Farms	+	-0.47 (0.34)	-0.34 (0.37)	-0.56 (0.36)	-0.50 (0.38)
Environmental Concern	+	0.16** (0.08)	0.19** (0.09)	0.16* (0.08)	0.16* (0.09)
Social Capital	+	0.14 (0.44)	0.15 (0.46)	0.14 (0.46)	0.09 (0.47)
Extension Agent Contact	+	0.67** (0.32)	0.67** (0.33)	0.76** (0.33)	0.78** (0.34)
Rotates Crops	+	0.14 (0.45)	0.01 (0.48)	0.25 (0.46)	0.20 (0.50)
Farm Sales ($10,000 - $50,000)			-0.27 (0.49)		-0.12 (0.51)
Farm Sales ($51,000 - $100,000)			-0.18 (0.53)		-0.21 (0.55)
Farm Sales ($101,000 - $250,000)			0.15 (0.46)		0.15 (0.47)
Percent Income From Farming >75%	+		-0.38 (0.38)		-0.47 (0.39)
High School Diploma or Above	+			0.98 (0.74)	1.04 (0.78)
Farmer's Age	_			-0.02 (0.01)	-0.02 (0.01)
Intercept		-1.94 (0.66)	-1.61 (0.77)	-1.86 (1.26)	-1.45 (1.37)
Psuedo - R2		0.20	0.20	0.23	0.24
-2 Log Likelihood		236.92	226.94	226.47	217.12
Chi-Square (df) for variables in the model		32.66 (7)***	31.48 (11)***	38.72 (9)***	37.70 (13)***
% WTC Correctly Predicted		70.7%	70.2%	70.9%	73.7%
# of Observations		208	198	203	194

Note: Standard Errors are in parentheses. %. The excluded Farm Sales Category is Farm Sales > $250,000.
* Significant at 10%, ** Significant at 5%, ***Significant at 1%

crop rotations on a county-wide scale (*perceived benefit*) are about 3.3 times more likely to work with their neighbors, 2.3 times more likely to participate in cooperative scouting, and 4.3 times more likely to participate in an effort to coordinate crop rotations on a county-wide basis than those who do not believe they can achieve more effective pest control by these efforts. *Perceived Benefit* is significant for all twelve models in our analysis, strongly supporting H1 (Table 3.5).

We find that Missouri crop farmers who rely on agricultural extension agents for pest control information indicated they are about 2.6 time more willing to cooperate with their neighbors to control pests, 3.0 times more willing to participate in cooperative scouting for pests, and 2.2 times more willing to cooperate in a county-wide effort to coordinate crop rotations than those who do not rely on agricultural extension agents for pest control information. *Extension Agent* is significant in all twelve models, strongly supporting H6 (Table 3.5). Additionally, farmers who are highly concerned about the affects pesticides may have on the environment indicated they are more willing to cooperate to control pests than those that are not as concerned about pesticides in the environment. Specifically, a one point increase in the environmental concern variable (which can be interpreted as one more pesticide-related environmental issue that the farmer was highly concerned about) corresponded to about a 130% increase in the farmers' stated WTC to control pests. In other words, a farmer who is highly concerned about 2 pesticide-related environmental issues was 1.3 times more likely to be willing to cooperate than a farmer who is only highly concerned about 1 pesticide-related environmental issue. *Environmental Concern* is significant in all twelve models, strongly supporting H7 (Table 3.5).

Missouri crop farmers who are active members in a community organization, such as a church or civic group, indicated they are about 6.4 times more willing to cooperate with their neighbors to control pests and 3.7 times more willing to participate in cooperative scouting than those that are not active members of a community organization. *Social Capital* is significant in eight out of twelve models in our analysis, supporting H4 (Table 3.5). Farmers who perceive their farms as being similar to their neighbors' farms say they are about 2.5 times more willing to cooperate with their neighbors to control pests than those who do not perceive their farms as similar to their neighbors' farms. *Similarity* is significant in four out of twelve models in our analysis, thus adding some support to H2 (Table 3.5).

To provide a sense of proportion on the relative importance of the significant predictor variables, we can also compare the coefficients of the dichotomous variables (all but *Environmental Concern*) (Tables 3.2-3.4). For example, the effect of *Social Capital* on farmers' WTC to work with their neighbors is about 1.5 times greater than the effect of *Perceived Benefit* and almost 2 times greater than the effect of *Similarity* or *Extension Agent*. In contrast, *Social Capital* and *Extension Agent* have the greatest effect on farmers' WTC in cooperative scouting. These variables' effect on WTC in cooperative scouting is about twice the effect of *Perceived Benefit* and triple the effect of *Similarity*. Finally, *Perceived Benefit* has the greatest effect on farmers' WTC in county-wide crop rotations with the effect of *Perceived Benefit* being twice that of *Extension Agent*. These results suggest that not only does the significance of the determinants vary for different

Table 3.5
Proposed hypotheses and analysis results regarding farmers' willingness to cooperate to control pests.

Hypothesis	Literature Base*	Hypothesis Supported by Analysis**	# of Models (of 12) Supporting Hypothesis***
H1: Farmers who perceive that they can achieve more effective pest control by working with their neighbors or by coordinating crop rotations on a county-wide scale will be more willing to participate in these cooperative pest control efforts than farmers who do not believe they can achieve more effective pest control by working with their neighbors or by rotating crops on a county-wide scale.	CA, AA, EM	Yes	12
H2: Farmers who perceive that their farm and farm operations are similar to their neighbors' farms and farm operations will be more willing to participate in cooperative pest control than farmers who perceive that their farm and farm operations are different than their neighbors' farms.	CA	Mixed Results	4
H3: Farmers who believe their neighbors or the farmers in their community are usually trustworthy will be more willing to participate in cooperative pest control than farmers who believe that their neighbors or the farmers in their community are only sometimes trustworthy or rarely trustworthy.	CA, EM	No	0
H4: Farmers who are active participants in a community organization will be more willing to participate in cooperative pest control than farmers who are not active members in a community organization.	CA, AA	Yes	8
H5: Farmers who currently scout their fields or rotate crops for pests will be more willing to participate in cooperative efforts that involve these IPM techniques than farmers who do not currently scout their fields or rotate crops.	AA	No	0
H6: Farmers who rely on agricultural extension agents for pest control information will be more willing to participate in cooperative pest control than farmers who do not rely on agricultural extension agents for pest control information.	AA, EM	Yes	12
H7: Farmers who are highly concerned about the affect pesticides have on certain environmental factors will be more willing to participate in cooperative pest control than farmers who are only somewhat concerned or are unconcerned about the affect pesticides have on these environmental factors.	AA, EM	Yes	12

*CA=Collective Action, AA=Agricultural Adoption, EM=ecosystem management

**This column was marked "yes" if all coefficients had the expected sign and the predictor variable was significant in at least one model, and "no" if the coefficients had the right sign but the predictor variable was never significant. "Mixed results" means some of the coefficients had unexpected signs.

***This column shows the number of models out of twelve where the predictor variable that corresponds to each hypothesis was significant and the coefficient had the expected sign.

types of cooperative pest control activities, but the relative importance of the determinants in comparison to each other varies, too.

The predictor variable that represents trust in our models, *Trusts Neighbors* or *Trusts Community Farmers,* and the predictor variable that represents familiarity with an IPM technique, *Scouts Fields* or *Rotates Crops,* are not significant in any model in our analysis (Table 3.5). Therefore, our analysis does not support H3 or H5.

Our results show no differences in the determinants that affect farmers' willingness to participate in general versus specific popular cooperative pest control efforts (Tables 3.2 and 3.3). However, we find differences in the determinants that affect popular versus unpopular efforts. Although the coefficients for *Similarity* had the expected sign in all eight models whose WTC variable represents a popular effort, the coefficients had the opposite sign in the four models whose WTC variable represents an unpopular effort (Table 3.4). In addition, one of our variables, *Social Capitol*, was significant for all eight models that reflect WTC in the popular cooperative pest control efforts (Tables 3.2 and 3.3). However, it was not significant in the four models that reflect WTC in an unpopular cooperative effort (Table 3.4).

Two of our control variables, annual farm sales and percent of total household income farmers received from agricultural production, may also be important determinants for some cooperative pest control efforts. We found that including these two control variables, along with farmers' age and education level, in our analysis increased the fit of our models and increased the percent of WTC responses correctly predicted for each analysis (Tables 3.2 - 3.4). We also found that farmers who received at least 75% of their total household income from agricultural production are about 4.5 times more willing to work with their neighbors to control pests than those farmers who received less than 75% of their total household income from agricultural production in two of our models (Table 3.2). Additionally, farmers whose annual farm sales were $50,000 - $100,000 are about 1.7 times more willing to work with their neighbors to control pests than those whose annual farm sales were greater than $250,000 in one model (Table 3.2). Farmers' age and education level were not significant in any of our models.

6. Discussion

The provision of the ES, pest control, in agricultural ecosystems is important for the long-term sustainability of crop production in the United States (Bianchi et al., 2006). Many scholars believe that natural pest control should be managed at the landscape level and include a coordinated effort between landowners to be effective (e.g. Tscharntke et al., 2005). Additionally, Stallman (2011) identifies pest control as highly suited for collective management. However, little is known about whether North American farmers are willing to cooperate to control pests, what types of cooperation they are willing to consider, what determinants may affect their willingness to cooperate, and whether those determinants follow the collective action, agricultural adoption and ecosystem management literature. This study fills this research gap by answering these questions.

We find that most Missouri crop farmers are willing to cooperate to control pests and that simple, local cooperative efforts, such as signing up to receive pest outbreak alerts from a regional pest coordinator, are more popular with farmers than formal, larger scale efforts, such as participating in a county-wide effort to coordinate the placement of pest predator rest and breeding habitat (Figure 3.1). We also find that the determinants that affect popular cooperative pest control efforts, may be different than the determinants that affect unpopular efforts.

Most importantly, we find that the determinants that affect WTC to control pests follow those predicted by collective action theory, the agricultural adoption literature and the ecosystem management literature. Specifically, we find that that farmers who believe they will receive a benefit from cooperation and who have strong social capital are more willing to cooperate than those that do not, as predicted by all three bodies of literature (Ostrom, 1990, 2009; Kahan, 2003; Pretty, 2003; Gedikoglu and McCann, 2010; Prokopy et al., 2008; Raedeke et al., 2001; Jacobson, 2002; Wondolleck and Yaffee, 2000). We find that farmers who are highly concerned about the affect pesticides may have on the environment are more willing to cooperate than those that are not concerned about the environment, as predicted by the agricultural adoption literature and the ecosystem management literature (Gedikoglu and McCann, 2010; Prokopy et al., 2008; Raedeke et al., 2001; Jacobson, 2002; Wondolleck and Yaffee, 2000). Additionally, we find that farmers who rely on agricultural extension agents for pest control information are more likely to participate in cooperative pest control than those that do not rely on agricultural extension agents, as predicted by the agricultural adoption and ecosystem management literature (Gedikoglu and McCann, 2010; Prokopy et al., 2008; Raedeke et al., 2001; Jacobson, 2002; Wondolleck and Yaffee, 2000). Finally, in four of our twelve models, we find that farmers who perceive that their farms and farm operations are similar to their neighbors' farms and farm operations are more willing to cooperate than those that do not perceive this similarity, as predicted by the collective action literature (Ostrom, 1990; 2009) (Table 3.5).

Only two of our seven predictor values, the one for trust (*Trusts Neighbors* or *Trusts Community Farmers)* and the one for familiarity *(Scouts Fields* or *Rotates Crops*) were not significant in any model in this study (Table 3.5). Collective action theory states that a person's trust in other members of a group affects the person's willingness to work with that group (e.g. Ostrom, 1990; Kahan 2003). It may seem that this aspect of collective action theory does not apply to cooperative pest control. However, this result only reflects one type of trust, a farmers' relational trust with neighbors and other ocal farmers. Scholars argue that trust is context or domain-specific, including scholars who study trust relationships in the context of collaborative natural resource management (e.g. Lubell, 2007). Thus, other types of trust may be important for farmers' WTC to control pests and should be explored in future studies.

The agricultural adoption literature, including the IPM adoption literature, states that experience or familiarity with a management practice increases the likelihood that the practice will be adopted (e.g. Rogers, 2003; Bonabana-Wabbi, 2002). Our study found that current experience with an IPM technique does not affect farmers' stated willingness to participate in cooperative pest control efforts that involves that technique (Table 3.5). This finding seems to contradict the agricultural adoption literature. However, the IPM techniques used in this study, scouting fields and rotating crops, have been used by farmers for decades to control pests (Apple and Smith, 1976). It is likely that many Missouri farmers are familiar with these techniques through educational programs, word of mouth or past experience, whether or not they are a current user. In addition, compatibility with current practices is also an important factor in agricultural adoption (e.g. Reimer et al., 2012). It is possible that current users of these IPM techniques may have established effective routines for scouting fields or rotating crops and did not find cooperation compatible with their current practices.

Our result show that not all cooperative pest control efforts are affected by the same determinants and should not be treated the same. Specifically, we find differences in the determinants that affect popular versus unpopular cooperative pest control efforts. It is possible, however, that these results reflect a difference between local versus county-wide efforts, instead of popular versus unpopular efforts, since all popular activities were local (or could be achieved from the farmers' home) and all unpopular activities were county-wide. *Social Capital* is one variable that may be affected by local versus regional differences. Many scholars agree that social capital can be location-specific and may not extend past the location where it was formed (e.g. Kan, 2007). In our study, farmers who are active participants in at least one local organization are more willing to cooperate in local pest control efforts than farmers who have not developed local social capital (Tables 3.2 and 3.3). However, *Social Capital* does not seem to extend past the local community where it was developed to affect willingness to participate in a county-wide pest control effort (Table 3.4).

We find that simple, informal and local efforts are more popular than more complex, formal and county-wide efforts (Figure 3.1). This may be because farmers prefer to put their efforts into local projects versus county-wide projects, but it may also reflect a perceived difference in the net benefits of participation. For example, many parasitoid and predator invertebrate species are most affected by landscape level processes within a 1 - 3 km radius (Schmidt et al., 2008; Schmidt and Tscharntke, 2005; Gardiner et al., 2009), so local efforts might be more effective than regional efforts in enhancing natural populations of pest predators that will benefit an individual farmer. Plus, local participation in a small-scale, simple activity is likely to have fewer costs than participation in a large-scale, county-wide effort (Ostrom, 1990). Although it was beyond the scope of this study to determine the specific costs and benefits of each cooperative pest control effort, our results suggest that farmers may have perceived differences in the costs and benefits of various cooperative efforts and answered our questions accordingly. Most research is needed to determine the specific costs and benefits of cooperation, and how these specific costs and benefits of cooperation affect farmers' WTC. For example, net benefits may differ by crop grown; farm size or land tenure; institutional factors; the farms' location in the landscape or cooperative; organizational characteristics of the cooperative; producer characteristics, such as risk-adversity and time spent on managerial activities; and resource characteristics, such as soil characteristics, and their interaction with pest populations and pest-predator populations (Ostrom, 1990, 2001; Lubell et al., 2002; Lubell, 2004; Fernandez-Cornejo, et al., 1994; Cong et al., 2014a; Cong et al, 2014b). More research is needed to determine how net benefits, including unequal net benefits for providers, may affect farmers' WTC to control pests.

The few cooperative pest control efforts documented in the literature began with the leadership of a social entrepreneur, such as an agricultural extension agent or a researcher, who helped organize the farmers into groups and provided technical support (e.g. Stemerding et al., 2002; Ayer, 1997). More research is needed to determine what types of trust are important to farmers who are considering cooperation to control pests, including which social entrepreneurs and supporting institutions may be most trusted or most accepted by farmers. In addition, further research is needed to determine farmers' attitudes and perceptions about landscape-level processes that affect pest control and how these attitudes affect the farmers' willingness to cooperate to provide that ES.

7. Conclusion

In this study, we fill a gap in the literature by answering four important questions about cooperative pest control: 1) are Missouri farmers willing to cooperate to control pests on their farms? 2) what types of cooperation are they willing to consider 3) what determinants affect their willingness to cooperate, and 4) do those determinants follow the predictions of collective action theory, the agricultural adoption literature and the ecosystem management literature? Although some scholars stress that regional pest control efforts may be desirable for effective and sustainable pest control (e.g. Cummings and Spiesman, 2006), we find that simple, local cooperative efforts may be more popular than formal, county-wide efforts. In addition, we find that the determinants that affect farmers' willingness to cooperate to control pests follow those predicted by the collective action literature, the agricultural adoption literature and the ecosystem management literature. Specifically, farmers who believe they will receive a benefit from cooperation, have farms similar to their neighbors' farms, are active members of a community organization, trust agricultural extension agents for pest control information, and are concerned about the affect pesticides may have on the environment are more willing to cooperate than farmers who do not share these characteristics.

This study is important because it is the first study to evaluate what determinants may influence North American farmers' willingness to cooperate to control pests, and the first study to explore and synthesize three diverse literatures to predict these determinants. In addition, this study may help encourage the formation of pest control cooperatives in the Midwestern US because it provides scholars, policy-makers and social entrepreneurs with needed information about what type of cooperation may be desirable or acceptable to farmers, which farmers should be targeted by cooperative pest control marketing campaigns, and what type of education or incentives may be necessary to convince farmers to cooperate. This study may also be important because it sheds light on farmers' willingness to cooperate to provide an ES and their willingness to consider landscape-level processes in the management of privately-owned land.

7. References:

Apple, J. L. and R. F. Smith (Eds.). 1976. *Integrated pest management*. New York: Plenum Press. 200pp.

Ayer, H. W. 1997. Grass roots collective action: agricultural opportunities. *Journal of Agricultural and Resource Economics* 22:1–11.

Bianchi, F., CJH Booij, and T. Tscharntke. 2006. Sustainable pest regulation in agricultural landscapes: a review on landscape composition, biodiversity and natural pest control. *Proceedings of the Royal Society B: Biological Sciences* 273(1595):1715.

Bonabana-Wabbi, J. 2002. *Assessing factors affecting adoption of agricultural technologies: The case of integrated pest management (IPM) in Kumi district*, *Eastern Uganda* (Doctoral dissertation, Virginia Polytechnic Institute and State University).

Cong, R. G., H. G. Smith, O. Olsson and M. Brady. 2014a. Managing ecosystem services for agriculture:Will landscape-scale management pay?. *Ecological Economics* 99:53-62.

Cong, R. G., K. Hedlund, H. Andersson, and M. Brady. 2014b. Managing soil natural capital: an effective strategy for mitigating future agricultural risks? *Agricultural Systems*, 129:30-39.

Cook, M. L. 1995. The future of US agricultural cooperatives: A neo-institutional approach. *American Journal of Agricultural Economics 77*(5):1153-1159.

Crowder, D.W., T. D. Northfield, M. R. Strand and W.E. Snyder. 2010. Organic agriculture promotes evenness and natural pest control. *Nature* 466:109–112.

Cumming, G., D. Cumming and C. Redman. 2006. Scale mismatches in social-ecological systems: causes, consequences, and solutions. *Ecology and Society 11*(1): 14.

Cumming, G. S., and B. J. Spiesman. 2006. Regional problems need integrated solutions: Pest management and conservation biology in agroecosystems. *Biological Conservation* 131(4):533-543.

Dent, D. (Ed.) 1995. *Integrated Pest Management*. Springer. 356pp.

Fernandez-Cornejo, J., E. D. Beach, and W. Y. Huang. 1994. The adoption of IPM techniques by vegetable growers in Florida, Michigan and Texas. *Journal of Agricultural and Applied Economics*, *26*:158-158.

Flint, M. L. 2012. *IPM in practice: principles and methods of integrated pest management*. Vol. 3418 UCANR Publications. 131 pp.

Gardiner, M. M., D. A. Landis, C. Gratton, C. D. DiFonzo, M. O'Neal, J. M. Chacon and G. E. Heimpel. 2009. Landscape diversity enhances biological control of an introduced crop pest in the north-central USA. *Ecological Applications* 19*:* 143-154.

Gedikoglu, H. and L. M. J. McCann. 2010. What causes farmers to adopt agricultural and conservation technologies and how can we use that knowledge to improve policies, programs and technologies. In: *Human Dimensions of Soil and Water Conservation: A Global Perspective.* Editor: T. L. Napier. Nova Science Publishers Inc.

Goldman, R. L., B. H. Thompson and G.C. Daily. 2007. Institutional incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. *Ecological Economics* 64:333-343.

Hendrickson, M. K. and H. S. James. 2005. The ethics of constrained choice: How the industrialization of agriculture impacts farming and farmer behavior. *Journal of Agricultural and Environmental Ethics* 18(3): 269-291.

Jacobson, M. G. 2002. Factors affecting private forest landowner interest in ecosystem management: linking spatial and survey data. *Environmental Management* 30(4): 577-583.

Kahan, D. M. 2003. The Logic of Reciprocity: Trust, Collective Action, and Law. *Michigan Law Review*, *102*(1):71–103.

Kan, K. 2007. Residential mobility and social capital. *Journal of Urban Economics, 61*(3):436-457.

Klingauf, F. A. 1988. Are Feasible Methods for an Ecological Pest Control in View? *Ecological Bulletins* (39):74-81.

Kramer, R. M., M. B. Brewer and B. A. Hanna. 1996. Collective trust and collective action. *Trust in organizations: Frontiers of theory and research* 357-389.

Kremen, C. 2005. Managing ecosystem services: what do we need to know about their ecology? *Ecology Letters* 8:468–479.

Landis, D. A., S. D. Wratten and G. M. Gurr. 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. *Annual review of entomology*. *45*(1):175-201.

Landis, D. A., M. M. Gardiner, W. Van der Werf, and S. M. Swinton. 2008. Increasing corn for biofuel production reduces biocontrol services in agricultural landscapes. *PNAS* 105 (51): 20552-20557

Lochner, K., I. Kawachi, and B. P. Kennedy. 1999. Social capital: a guide to its measurement. *Health and Place 5*(4):259-270.

Lubell, M., M. Schneider, J. T. Scholz, and M. Mete. 2002. Watershed partnerships and the emergence of collective action institutions. *American Journal of Political Science* 46(1): 148-163.

Lubell, M. 2004. Collaborative watershed management: A view from the grassroots. *Policy Studies Journal* 32(3):341-361.

Lubell, M. 2007. Familiarity breeds trust: Collective action in a policy domain. *Journal of Politics*, 69(1): 237–250.

Matson, P. A., W. J. Parton, A. G. Power and M. J. Swift. 1997. Agricultural Intensification and Ecosystem Properties. *Science* 277(5325):504 -509.

MU Plant Sciences. 2012. *MU Pest Monitoring Network: Integrated Pest Management.* Retrieved from http://ipm.missouri.edu/pestmonitoring

Nabhan, G.P. and S.L. Buchmann. 1997. Pollination services: Biodiversity's direct link to world food stability. Pages 133-150 in G. Daily, editor. *Nature's Services: Societal Dependence on Natural Ecosystems.* Island Press, Washington, D.C.

Naylor, R. L. and P. R. Ehrlich. 1997. Natural Pest Control Services and Agriculture. Pages 151-174 in G. Daily, editor. *Nature's Services: Societal Dependence on Natural Ecosystems.* Island Press, Washington, D.C.

Östman Ö, B. Ekbom and J. Bengtsson. 2003. Yield Increase Attributable to Aphid Predation by Ground-living Polyphagous Natural Enemies in Spring Barley in Sweden. *Ecological Economics* 45:149-148.

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.

Ostrom, E. 2001. Reformulating the Commons. In *Protecting the Commons: A Framework for Resource Management in the Americas*, ed. Joanna Burger, Elinor Ostrom, Richard B. Norgaard, David Policansky,and Bernard D. Goldstein. Washington, DC: Island Press, 17–41.

Ostrom, E. 2009. Analyzing Collective Action. Keynote papers presented in the Plenary Sessions of the 27th Conference of the International Association of Agricultural Economists. 16-22 August 2009, Beijing, China.

Pelosi, C., M. Goulard and G. Balent. 2010. The spatial scale mismatch between ecological processes and agricultural management: Do difficulties come from underlying theoretical frameworks? *Agriculture, Ecosystems & Environment* 139(4):455-462.

Phan, M. B. 2008. We're all in this together: context, contacts, and social trust in Canada. *Analyses of Social Issues and Public Policy 8*(1):23-51.

Pickett, C. H. and R. L. Bugg (eds.). 1998. *Enhancing biological control: habitat management to promote natural enemies of agricultural pests*. University of California Press. 427 pp.

Pontius, J., Dilts, R. and A. Bartlett (eds.). 2002**.** *From farmer field schools to community IPM: ten years of IPM training in Asia.* FAO Regional Office, Bangkok, Thailand.

Pretty, J. 2003. Social Capital and the collective management of resources. *Science* 302:1912-1914.

Prokopy, L. S., K. Floress, D. Klotthor-Weinkauf, and A. Baumgart-Getz. 2008. Determinants of Agricultural Best Management Practice Adoption: Evidence from the Literature. *Journal of Soil and Water Conservation* 63(5): 300–311.

Raedeke, A. H., C. H. Nilon, and J. S. Rikoon. 2001. Factors affecting landowner participation in ecosystem management: a case study in south-central Missouri. *Wildlife Society Bulletin* 29(1): 195-206.

Ravnborg, H. M. 2004. Collective Action in Pest Management. Brief 11 in Meinzen-Dick, R. and M. Di Gregorio editors. *Collective action and property rights for sustainable development.* Feldafing, Germany: DSE./ZEL.

Reimer, A. P., D. K. Weinkauf, and L. S. Prokopy. 2012. The influence of perceptions of practice characteristics: An examination of agricultural best management practice adoption in two Indiana watersheds. *Journal of Rural Studies*, *28*(1):118-128.

Rogers, E. M. 2003. *Diffusion of Innovations*. 5th Edition. Simon and Schuster. 553 pgs.

Roland, J. and P. D. Taylor. 1997. Insect parasitoid species respond to forest structure at different spatial scales. *Nature* 386:710–13

Schmidt, M. H., C. Thies, W. Nentwig and T. Tscharntke. 2008. Contrasting responses of arable spiders to the landscape matrix at different spatial scales. *Journal of Biogeography* 35: 157-166.

Schmidt, M. H. and T. Tscharntke. 2005. Landscape context of sheetweb spider (Araneae: Linyphiidae) abundance in cereal fields. *Journal of Biogeography* 32:467–473

Staatz, J. M. 1987. Farmers' incentives to take collective action via cooperatives: a transaction cost approach. *Cooperative theory: New approaches* 18: 87-10

Stallman, H. R. 2011. Ecosystem services in agriculture: Determining suitability for provision by collective management. *Ecological Economics* 71:131-139.

Stemerding, P., A. Musch, and Y. Diarra. 2002. *c* FAO. Rome. 46 pgs.

Sunding, D., and D. Zilberman. 2001. The agricultural innovation process: research and technology adoption in a changing agricultural sector. *Handbook of Agricultural Economics 1*:207-261.

Tette, J., J. Kovach, M. Schwartz and D. Bruno. 1987. IPM in New York Apple Orchards-Development, Demonstration, and Adoption. *New York's Food and Life Sciences Bulletin* 119. http://hdl.handle.net/1813/5150

Tillman, D., K.G. Cassman, P.A. Matson, R. Naylor and S. Polasky. 2002. Agricultural sustainability and intensive production practices. *Nature* 418:671–677.

Tscharntke, T., A. Klein, A. Kruess, I. Steffan-Dewenter & C. Thies. 2005. Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. *Ecology Letters* 8:857–874.

Tscharntke, T., R. Bommarco, Y. Clough, T. O. Crist, D. Kleijn, T. A. Rand and S. Vidal. 2007. Conservation biological control and enemy diversity on a landscape scale. *Biological control*, 43(3): 294-309.

Wilby, A. and M. B. Thomas. 2002 Natural enemy diversity and pest control: patterns of pest emergence with agricultural intensification. *Ecology Letters* 5: 353–360.

Wilson, C. and C. Tisdell. 2001. Why farmers continue to use pesticides despite environmental, health and sustainability costs. *Ecological economics*, *39*(3):449-462.

Wondolleck, J. M. and S. L. Yaffee. 2000. *Making collaboration work: Lessons from innovation in natural resource management.* Washington, D.C.: Island Press. 277 p.

Zalucki, M. P., Adamson, D., & Furlong, M. J. 2009. The future of IPM: whither or wither? *Australian Journal of Entomology*, *48*(2):85-96.

Zhang, W., T. H. Ricketts, C. Kremen, K. Carney, and S. M Swinton. 2007. Ecosystem services and Dis-services to agriculture. *Ecological Economics* 64:253–260.

CHAPTER FOUR

Farmers' Willingness to Cooperate to Control Pests: Does Trust Matter?

Abstract: Ecosystem service provision in agriculture may require cooperation between farmers. Trust fosters cooperation in many economic and social interactions and is important to the success of traditional agricultural cooperatives. Little is known, however, about how trust affects farmers' willingness to cooperate to provide an ecosystem service, such as pest control, what types of trust are most important, and under what conditions trust may matter. In this study, we survey 229 Missouri crop farmers to explore the role trust plays in farmers' stated willingness to cooperate to control pests. We find that most farmers say they are willing to cooperate and most farmers are willing to trust others. However, we find little evidence to support our hypothesis that trust positively influences farmers' willingness to cooperate to control pests. Instead, we find weak evidence that trust affects different types of cooperative pest control in different ways. We find that trust may only matter under certain conditions, such as when participants' farms are dissimilar. We also find that other determinants, such as the perceived benefit of cooperation and environmental concern, are more important than trust to farmers who are contemplating cooperation to control pests.

Keywords: trust, collective action, ecosystem services, cooperative pest control, agriculture, willingness to cooperate

1. Introduction: Trust fosters cooperation in many social and economic interactions and may be necessary for collective action to occur (Kahan, 2003; Hardin, 2002; Gambetta, 2000; Jones and George, 1998; Ostrom, 1990; Arrow, 1974). Scholars agree that trust is a crucial component in the success of traditional agricultural cooperatives, where farmers work together in order to achieve a benefit they could not achieve in the market alone (e.g. Jones, 2004). Trust affects farmers' decisions to join or exit agricultural cooperatives, their satisfaction with the cooperatives, how the cooperatives are structured, how successful the cooperatives are, and whether or not members market their products to the cooperatives (Osterburg and Nilsson, 2009; Nilsson et al., 2009; James and Sykuta, 2006, 2005; Jones, 2004; Hansen et al., 2002; Ole Borgen, 2001).

Trust also affects farmers' willingness to participate in other forms of collective action, including those designed to provide positive environmental outcomes as well as positive economic outcomes (Pretty and Ward, 2001; Ostrom, 1990). For example, Marshall (2004) found that farmers were more willing to implement recommended irrigation management plans on their farms as part of a collaborative effort to reduce salinity when they trusted that other farmers would also cooperate with the plans. In fact, trust in other participants' cooperation was more important than materialistic motivations in farmers' willingness to cooperate. Likewise, Lundqvist (2001) found that farmers refused to cooperate with each other to improve water quality in catchments threatened by severe eutrophication from fertilizer use, despite the threat of draconian measures from central authorities and other incentives to engage in collective action, because a long history of failed reciprocity led to a culture of distrust among farmers in the catchment.

While trust appears to be important to farmers who are considering cooperation to achieve mutual goals, what is not clear is the affect different types of trust have on farmers' willingness to cooperate to provide positive environmental outcomes, such as ecosystem service (ES) provision. Behavioral scientists often disagree on the definition of trust, but they do agree that there are different types of trust (Rousseau et al., 1998) and that different types of trust may have different effects on the outcome of social or economic interactions (Zaheer et al., 2008; Zhu et al., 2013; Stern, 2010). Few scholars, however, have explored the role of different types of trust on the success of collective action between farmers in the management of natural resources or ES.

In this paper, we explore the affect different types of trust have on farmers' stated willingness to cooperate to provide the ES pest control. Cooperation between farmers may be important because many agricultural-related ES, including pest control, require landscape-level management and a coordinated effort between farmers for effective provision, especially in areas of intensive agricultural production (Cong et al., 2014a; Goldman, 2007; Tscharntke et al., 2005). Proponents of cooperative solutions often point to the spatial scale-mismatch between ES and agriculture as justification for the necessity of cooperation (e.g. Goldman, 2007). In other words, the spatial scale of management in agricultural ecosystems (e.g. a 500 acre farm) often does not match the spatial scale of ecosystem processes necessary to provide an ES (e.g. a tri-county watershed), making cooperation among farmers necessary (Pelosi et al., 2010; Cumming et al., 2006). Additionally, Cong et al. (2014a) found that landscape-level management of some ES, such as those provided by mobile organisms (e.g. pollination services), is more profitable than farm-level management for all farmers within the landscape.

As the potential benefits of cooperative ES provision become clear, scholars have shown increasing interest in the determinants that affect cooperative provision of agricultural-related ES (e.g. Uetake, 2014; Stallman and James, 2015). Some of these studies have begun to explore the role of trust in cooperative provision, especially in large-scale initiatives where farmers work with other stakeholders to improve water quality, biodiversity or wildlife recreation (e.g. Lubell, 2007). Whether these studies are framed as an ecosystem service (ES) provision problem, or as a mitigation strategy for the unintended side-effects of intensive agriculture, they show that trust affects the success of farmers' cooperative efforts to provide ES, including the initial recruitment of landowner participants (Stern and Coleman, 2014; Lundqvist, 2001; Marshall, 2004; Raedecke et al., 2001). There is little research, however, on the role of trust in informal or small-scale cooperative ES provision, which is the likely form cooperative pest control will take (e.g. Stemerding, 2002; Stallman and James, 2015). In addition, there is little research on what types of trust might matter.

Stallman and James (2015) found that one type of trust, the perceived trustworthiness of one's neighbors, did not affect Missouri farmers' stated willingness to participate in cooperative pest control. However, no study has looked at the affect different types of trust may play in a farmers' willingness to cooperate to control pests. This study aims to fill that gap by 1) assessing if trust is an important determinant in a farmers' stated willingness to cooperate to control pests, 2) determining how different types of trust affect farmers' willingness to cooperate to control pests and 3) exploring under what conditions trust may matter to farmers who are considering participation in cooperative pest control.

We use a survey of 229 Missouri crop farmers to answer our research questions. This study is important because the management of natural capital, including agricultural-related ES, may rely on farmer cooperation, which may in turn rely on trust between participants (Pretty and Ward, 2001). This study takes a first important step in understanding the role that different types trust may play in the recruitment phase of farmers in a cooperative pest control initiatives in the Mid-western United States.

2. Background Literature

2.1 Cooperative Pest Control: Scholars agree that cooperative integrated pest management (IPM) is a likely path that cooperative pest control will take in North

America (e.g. Cumming and Spiesman, 2006). IPM is a pest management system that requires monitoring pest populations and taking actions, such as pesticide application or cultural control, only when a certain threshold is reached (Flint, 2012; Dent, 1995). IPM was designed to consider multiple pest management goals, including economic, social, and environmental goals, such as increased natural pest control (Dent, 1995). It has been practiced cooperatively by subsistence farmers and small-scale producers in parts of Asia and Africa (van de Fliert, 1997, Stemerding et al., 2002; Pontius et al., 2002). Plus, it is highly suited to cooperation (Cumming and Spiesman, 2006).

IPM as it is currently practiced in North America rarely includes a cooperative element, but Cumming and Spiesman (2006) offer insights about how it could be re-envisioned as a greater cooperative effort between farmers to provide enhanced regional pest control, including enhanced natural pest control. They argue that the greatest limitation of IPM the way it is currently practiced is that it does not effectively integrate landscape-level ecosystem processes into its design. To be truly effective, they argue IPM must be practiced on a regional scale where landowners 1) cooperate in scouting for pest outbreaks, 2) coordinate the amount, spacing and landscape-configuration of pest predator breeding and rest habitat within the region, 3) coordinate crop rotation on a regional level 4) coordinate the number of acres and the landscape configuration of acres planted to a single crop 5) coordinate the minimal use of least-toxic pesticides and 6) coordinate the release of biological controls that will enhance the natural pest control processes already operating in the region (Cumming and Spiesman, 2006). By integrating these cooperative practices into IPM, Cumming and Spiesman (2006) argue that a more robust form of pest management could be achieved, leading to a greater ability of agricultural ecosystems to sustain long-term production of food, fuel, and fiber.

Some agricultural extension programs in the United States incorporate an element of cooperative pest scouting into their program. For example, the University of Missouri's IPM program offers farmers the opportunity to sign up to receive pest alerts, where farmers are informed by email when an agricultural extension agent has discovered a pest outbreak within their county (MU Plant Sciences, 2012). In addition, two studies have documented North American farmers' participation in IPM-related pest control cooperatives, including cotton growers in Arizona and apple growers in New York (Ayer, 1997; Tette et al., 1987). In both of these cases, the cooperative's main function was to pool its members' financial resources to hire a pest control manager who facilitated the application of integrated pest management techniques by individual farmers on their individual farms (Tette et al., 1987; Ayer, 1997). However, some pest control districts in Arizona make collective management decisions that all members are encouraged to abide by, such as setting pest damage thresholds for pesticide application and by using a board of growers to make pesticide application recommendations (Ayer, 1997).

2.2 Trust: Although trust has been conceptualized in many different ways in the behavioral science literatures, a useful definition of trust for our purposes is the "*psychological state in which one actor (the trustor) accepts some form of vulnerability based upon positive expectations of the intentions or behavior of another (the trustee), despite inherent uncertainties in that expectation"* (Stern and Coleman, 2014, pg. 119). In other words, a trustor expects a trustee to act in a positive way in a situation where the trustor stands to lose something and where the trustee's actions are uncertain.

This definition highlights three elements of trust that most scholars agree are important: 1) the willingness of the trustor to be vulnerable, 2) the expectation of a positive outcome, and 3) the conditions of uncertainty or risk (Hardin, 2002; Battachaya et al., 1998; Bigley and Pierce, 1998; Rousseau et al., 1998). In the context of cooperative pest control, a farmer (the trustor) may experience reduced yields due to pest outbreaks (vulnerability) if other farmers or stakeholders (trustees) cannot follow through, or choose not follow through (uncertainty), with agreed-upon cooperative activities, such as planting pest predator habitat or spraying pesticides at agreed-upon times or thresholds. If the farmer (trustor) chooses to participate in cooperative pest control anyway, this implies a rational belief that the benefits will outweigh the costs (expected positive outcome), which by definition implies some level of trust that others (trustees) will follow-through on their commitments.

3. Conceptual Framework

In this study we explore the affect different types of trust have on Missouri crop farmers' willingness to cooperate (WTC) to control pests. Conceptually, our model is a farmer's WTC is a function of trust, other predictor variables, and farmer and farm characteristics.

Our trust variables represent four of the five types of trust often considered important by social scientists and resource managers. Although scholars do not agree on a common definition of trust, they do agree that not all trust is the same (e.g. McNight and Chervany, 2000). For example, some farmers may trust farmers in their community to tell the truth, but not trust the same farmers to thoroughly scout their fields for pests. Other farmers may trust their local fish and wildlife agents, but not trust the agency the agents represent. Still other farmers may believe that most people can be trusted, but not trust their next-door neighbors. In each case, a different type of trust may be important for farmers who are considering whether or not to cooperate with other farmers to provide an ES, such as pest control.

Scholars have assigned many names and definitions to the different types of trusts, at the same time devising numerous typologies. Here we review the five types of trust that are most often discussed in the literature and that may be important to farmers who are considering cooperation to control pests. After each trust type, we include specific hypothesis for that type of trust.

3.1 General Trust: General trust is also called a disposition to trust or the propensity to trust, and can be described as "*the extent to which one displays a consistent tendency to be willing to depend on general others across a broad spectrum of situations and persons"* (McNight and Chervany, 2000, pg. 830). General trust may stem from a belief that other people are usually well-meaning and dependable, or it may be a personal choice that stems from the belief that one will achieve more desirable outcomes when one treats others as if they were well-meaning and reliable (Rousseau et al., 1998). In the context of cooperative pest control, a farmer who has general trust may trust every participant in the pest control cooperative to do his or her part until a participant gives the farmer a reason not to trust.

General trust is a stable individual characteristic (Rotter, 1980) that leads people to get involved in organizations and to derive satisfaction and other benefits from these organizations (Van Dyne et al., 2000). People with high general trust tend to take more risks, to perform better at their jobs, and to work better on teams than people with low general trust (Colquitt et al., 2007; Costa et al., 2001). People who have high general trust are also more likely to engage in collective action or to cooperate with others (Ostrom, 2014). Therefore, we hypothesize that farmers with high general trust will be more willing to cooperate to control pests than farmers with low general trust. Specifically, we hypothesize:

> **H1:** Farmers who believe that "most people can be trusted" are more likely to indicate a willingness to cooperate to control pests than farmers who believe that "you need to be very careful in dealing with people."

3.2 Relational Trust: Relational trust, also called personal trust, history-based trust, affective trust or identity-based trust, *means that a person believes that another person will act in the trustor's best interests because the trustor and trustee have built a relationship based on repeated interactions over time in which trust was given and rewarded* (Rousseau et al., 1998). The relationship between trustor and trustee often includes emotions, attachment, and a perception of trustworthiness based on reciprocated care and concern built from repeated interactions over time (McAllistar, 1995; Kramer, 1999). Examples of farmer-based relational trust may include trust between a farmer and his farm laborers, between a farmer and her neighbors, or between a farmer and a community business owner. In each case the trust has built from within the relationship as trustor and trustee have interacted over time (Rousseau et al., 1998).

Most scholars agree that relational trust reduces transaction costs in organizations or groups, making cooperation less costly and therefore, more likely (e.g. Kramer, 1999;

Cook et al., 2005). Relational trust can increase a person's tendency to join groups (Putnum, 1995), and can lead to cooperative behaviors that enhance the collective well-being of the group and the attainment of collective goals (Kramer, 1999; McAllister, 1995). In addition, relational trust increases cooperation beyond the level expected by general trust alone (Acedo-Carmona and Gomila, 2014). Plus, relational trust is important in landowner's involvement in local natural resource planning and management efforts (Payton et al., 2005).

In the context of cooperative pest control, farmers may have developed relational trust, or a perception of trustworthiness, with numerous other potential participants, including the farmers' neighbors, other farmers in the community, non-farmer community members, and social entrepreneurs who may help organize the farmers into groups and provide educational and technical support in the development of pest management cooperatives (e.g. Stemerding et al., 2002; Ayer, 1997). These social entrepreneurs may be representatives from various agencies that are stakeholders in how pests are managed in agriculture, including fish and wildlife conservation agents, water conservation agents, or agricultural extension agents. We hypothesize that farmers who have developed relational trust, or a perception of trustworthiness, with one or more of these potential participants will be more likely to cooperate to control pests than farmers who have not. Specifically, we hypothesize:

> **H2:** Famers who believe that other farmers in their community are usually trustworthy are more likely to be willing to cooperate to control pests than farmers who believe that other farmers in their community are sometimes trustworthy or rarely trustworthy.

H3: Famers who believe that non-farmers in their community are usually trustworthy are more likely to be willing to cooperate to control pests than farmers who believe that non-farmers in their community are sometimes trustworthy or rarely trustworthy.

H4: Famers who believe that fish and wildlife conservation agents are usually trustworthy are more likely to be willing to cooperate to control pests than farmers who believe that fish and wildlife conservation agents are sometimes trustworthy or rarely trustworthy.

3.3 Institutional Trust: Also called deterrence-based trust, systems-based trust or procedural trust, institutional trust can be described as *a belief that "the needed conditions are in place to enable one to anticipate a successful outcome in an endeavor or aspect of one's life"* (McNight and Chervany, 2000, pg. 830). These conditions may include contracts, rules, laws, sanctions, social roles, or norms of behavior that govern how people behave in a given situation (Stern and Coleman, 2015; McNight and Chervany, 2000; Rousseau et al., 1998). Institutional trust may also include the belief that a control system, such as a local government, has the will and ability to enforce the rules, and that the control system establishes the rules with transparency or fairness (Stern and Coleman, 2015). Institutions often make it too costly for an individual to renege on an expected course of action that the individual has been entrusted to take. In the context of cooperative pest control, a farmer who joins a regional pest control district with a governing board (see Ayers, 1997) may trust that other farmers are following the governing boards' pesticide use recommendations because they've signed contracts to do so and are subject to fines or other sanctions if they do not follow through. In a less formal setting, institutional trust may mean that a farmer expects her neighbors to follow through on agreed-upon cooperative pest control efforts, such as scouting common field borders, because the farmer believes that her neighbors are interested in preserving their good reputation in the community. In both of these examples, norms of behavior, sanctions or other institutions give the farmer confidence to expect that other actors will do their part within the cooperative agreement.

Most scholars agree that institutional trust fosters cooperation and a willingness to engage in collective action (e.g. Ostrom, 2014, 1990), while a distrust in institutions, such as distrust in a state government, may decrease willingness to cooperate (e.g. Davenport et al., 2007). For example, Palmer, Fozdar and Sully (2009) found that farmers with a strong distrust in the federal government were unwilling to cooperate in an effort to report and prevent the spread of infectious diseases in livestock in Australia. In addition, Lubell (2004) found that trust in local government affected farmers willingness to participate in a collaborative watershed project in Florida, while trust in the federal government did not. We hypothesize that farmers who trust the government officials in their community will be more likely to participate in cooperative pest control than those that don't trust their local government officials. Specifically, we hypothesize:

> **H5:** Famers who believe that their local government officials are usually trustworthy are more likely to be willing to cooperate to control pests than farmers who believe that their government officials are sometimes trustworthy or rarely trustworthy.

3.4 Trusting Beliefs: Also called affinitive trust, trusting beliefs *"means one believes (and feels confident in believing) that the other person has one or more traits that are desirable in a situation in which negative consequences are possible"* (McNight and Chervany, 2000, pg.831). These positive traits may include any trait that a farmer finds desirable in a person that the farmer must depend on, such as perseverance, integrity, benevolence, or competence (Stern and Coleman, 2015; McNight and Chervany, 2000). In this type of trust, it is the trait itself that makes the person trustworthy, not repeated interactions that have resulted in a pattern of rewarded trust (see relational trust above). In other words, someone who has trusting beliefs might trust every person she perceives as benevolent or competent, even if she just met the person. In the context of cooperative pest control, this might mean that a farmer who believes other farmers in his community possess traits such as integrity or competence may be more willing to depend on their ability to scout their fields thoroughly and to share those scouting reports in a timely manner, than the farmer would be if he did not believe other farmers were honest or competent.

For this study, we consider the trusting belief, integrity. To believe someone has integrity means that *"one believes the other person makes good faith agreements, tells the truth, and fulfills promises"* (McNight and Chervany, 2000, pg. 831). Minkler and Miceli (2004) found that high integrity among participants in a group fosters cooperation among group members, while Morgan and Hunt (1994) found that confidence in the integrity of relational marketing partners, increased cooperation between the two. Additionally, the perceived integrity of a business partner fosters economic exchange and consumer loyalty in ecommerce (Lee and Turbin, 2001). We hypothesize that farmers who possess trusting beliefs in the integrity of other participants are more likely to indicate a willingness to cooperate to control pests than farmers who do not have trusting beliefs. Specifically, we hypothesize:

> **H6:** Farmers who believe other farmers have a high level of integrity are more likely to indicate a willingness to cooperate to control pests than farmers who believe other farmers have a moderate or low level of integrity.

<u>3.5 Rational Trust:</u> Also called calculus-based trust, rational trust can be described *as a belief that another person will behave in a way that will bring the trustor a positive benefit* (Rousseau et al., 1998; Stern and Coleman, 2014). In other words, rational trust "is based primarily on the calculation of the perceived utility of the expected outcome of placing one's trust in another entity" (Stern and Coleman, 2015, pg. 122). Rational trust stems from credible outside information about past interactions of the trustee, the trustee's competence, the institutions that govern the interaction, and the expected costs and benefits for both the trustor and trustee (Stern and Coleman, 2015; Rousseau et al., 1998). Rational trust may overlap with institutional trust because some of the costs of an action or inaction may be sanctions or a loss of reputation. In addition, rational trust may overlap with relational trust because personal knowledge of the trustee and the relationship between trustor and trustee may factor into the utility equation. However, the institutional environment and personal knowledge are only two of the many considerations in a rational calculation of the expected utility of trusting. In fact, prior information from an outside credible source, such as a certification, may be more important in the development of rational trust (Rousseau et al., 1998). In the context of

cooperative pest control, rational trust may mean that a farmer trusts his neighbor to follow through on an agreement to share scouting reports because he believes his neighbor will receive a benefit from doing so, and in turn, the farmer will benefit also.

We do not consider rational trust as a separate construct in this study because rational trust is based on a calculation of the costs and benefits of trusting. These costs and benefits are partially captured by other trust variables, such as *Trust Government Officials*, and by some of our control variables, such as *Perceived Benefit*, which was found important in a study by Stallman and James (2015).

<u>3.6 Overall Trust:</u> A common alternative approach to considering different trust types is to consider types of trust and trust-warranting beliefs as measurements of a single underlying concept of trust. In fact, equating the concept of trust with a variety of measurements about trust-warranting properties or other beliefs is a common measurement approach in the trust literature. For example, Brehm and Rahn (1997) construct a 3-item interpersonal trust scale that includes a question about trustworthiness, fairness, and helpfulness of other people, while Lubell (2007) constructs a similar 4-item trust scale in a study about farmers' willingness to cooperate in a water quality initiative in California. Similarly, we construct a 6-item trust index from the trust types in hypothesis 1- 6. We interpret a high trust index score to mean that the respondent has a high overall level of trust, while a low trust index score corresponds with a low overall level of trust. Consiistent with hypothesis 1 - 6, we hypothesize:

H7: Farmers who score high on an overall trust index are more likely to indicate a willingness to cooperate to control pests than farmers who score low on an overall trust index.

3.7 Control Variables: In addition to the trust variables, our model includes five other predictor variables and two farm characteristic variables that were identified by Stallman and James (2015) as important determinants for farmer participation in cooperative pest control. We also include a farmer characteristic, preference for working in groups or working alone, which we identified as a potentially important determinant in farmers' willingness to cooperate from the management and education literature (e.g. Liu et al., 2007; Shaw et al., 2000).

3.8 Interaction Terms: Finally, our model includes interactions between our trust variables and two control variables that are often linked with trust in the literature: *Similarity* and *Likes to work in groups*. According to Sabatier and Jenkins-Smith (1993), people will trust actors who they believe have similar beliefs and interests to their own, and this trust will decline as the difference in policy-core beliefs increases (Leach and Sabatier, 2005). Likewise, Liu et al. (2007) found that students who had a preference for group work had a much higher propensity to trust group members when working in teams than those who preferred to work alone. Although we contend that similarity, a preference for group work, and trust are separate constructs, it is possible that the trustworthiness of a farmer's neighbor may only become important when their farms are dissimilar or when farmers have a preference for solo work. Because of the large number of possible interactions and the lack of previous studies to make predictions from, we do not pose hypothesis based on our interaction terms in this study.

4. Methods

We surveyed a random sample of 1,000 agricultural producers from Missouri with farm sales greater than $10,000 in 2011. The random sample was drawn by the National Agricultural Statistical Service (NASS) from a sample population that included all producers in Missouri who grew crops, such as corn and vegetables, except for the following exclusions. We did not include landowners who did not farm the land themselves or farmers who produced only livestock plus hay for that livestock. We disproportionately sampled fruit and vegetable farmers to make sure they were adequately represented in the sample. Additionally, we excluded farmers who lived in counties with low crop production (average MO county-size = 598 square miles). Instead, we only included those producers who lived in counties with moderate to high crop production where farmers are likely to have producers with whom to cooperate in both local and county-wide efforts. From 2007 – 2011, most Missouri counties either had < 5,000 acres in production or > 10,000 acres in production per year for both corn and soybeans. We chose to define high to moderate crop production as counties that had > 10,000 acres in production per year for both corn and soybeans for at least 3 out of the 4 years prior to the study. This gave us a total of 77 included counties and 37 excluded counties, which were predominantly urban or Ozark forest. The excluded counties also recorded low acres in production for wheat, cotton and sorghum, often so low that total acres in production for these crops wasn't reported for the county.

We sent our first wave of surveys with a request for participation to the random sample of 1000 agricultural producers from our sample population in early November of 2012. A second letter and survey were sent to all 1000 producers four weeks later with a second request for participation. We had a return rate of 30%, which is not unusual for Midwestern farmers (i.e. Hendrickson and James, 2005). Of the 300 returned surveys, 229 were useable for this study. Our pool of respondents produced all major crop types grown in Missouri, including corn, soybeans, wheat, hay, cotton, tobacco, sorghum, vegetables and fruit (especially melons and grapes). Our respondents' average age was 59.1 years, which is slightly higher than the average age of Missouri agricultural producers in 2012 (MO average =58.3 years). Our respondents were 96% male, which is also higher than the percent of male principle farm operators in Missouri in 2012 (89%). In addition, the median farm sales category for our respondents was the $50,000 - $100,000 annual sales category which corresponds to the average farm sales for all Missouri agricultural producers in 2012 ($95,680). Thus, our respondents are likely a representative sample of Missouri crop farmers, with the exception that we had fewer female respondents than expected. This may be because we disproportionately sampled fruit and vegetable farmers, because we excluded producers from counties with low crop production, because we excluded farmers whose farm income was less than $10,000, or because we excluded farmers who produced only livestock.

The survey instrument was designed to collect information about the producers' farm operations, their attitudes and perceptions about pests and pesticide use, their willingness to cooperate to control pests, and their willingness to trust. Question regarding trust and community involvement were placed in the last section of the survey and included questions about the respondents' general propensity to trust, farmer integrity, trustworthiness of various community members who may be involved in cooperative pest control, the farmer's involvement in community organizations, and how similar the respondents' farming operations were to neighboring farms. These questions were garnered from the literature and reflect standard questions that researchers have used to measure general trust, relational trust, community involvement etc. (e.g. Nannestad, 2008; Phan, 2008; Lochner et al., 1999).

The questions regarding WTC reflect current cooperative opportunities for Missouri farmers in the University of Missouri Agricultural Extension IPM Program (MU Plant Sciences, 2012), cooperative pest control efforts that have been successful in other states and countries (e.g. Ayer, 1997) and potentially desirable cooperative efforts as outlined by Cumming and Spiesman (2006). The WTC questions explored the farmers' willingness to participate in such activities as cooperative scouting, coordinated pesticide application, coordinated release of biological pest controls, coordinated crop rotations, coordinated crop diversity initiatives and coordinated placement of pest predator habitat. All regional efforts were defined as county-wide efforts on the survey (average MO county-size = 598 square miles), so that the respondents had a familiar and common frame of reference for a regional effort, not because we believe a political border such as a county is the most ecologically important way to delineate cooperative efforts. Farmers were provided with a list of these voluntary cooperative pest control activities and were asked to what degree (based on a Likert scale from 1 - 5) they were willing (=1) or unwilling (=5) to participate in the activity.

Definitions and summary statistics for our WTC variables as well as our trust variables and control variables are given in Table 1. Our dependent variables are binary variables constructed from individual questions concerning a producer's willingness to participate in one of three voluntary, cooperative pest control efforts: cooperative scouting for pests with the farmer's neighbors and other local farmers (*Cooperative Scouting*), coordinating crop rotations on a county-wide scale (*County-wide Crop Rotations*), and coordinating pesticide use with other local farmers (*Coordinate Pesticide Use*). We chose these three WTC variables because they represent diverse cooperative efforts with varying popularity among Missouri farmers. Specifically, we chose one popular effort (*Cooperative Scouting* with 69% of farmers WTC), one moderately popular effort (*Coordinate Pesticide Use* with 54% WTC) and one unpopular effort (*County-wide Crop Rotations* with 36%WTC) (Table 4.1).

Our trust variables are either binary or continuous variables, based on a single survey question or a series of related questions (Table 4.1). Specifically, the trust variables for our analysis are a set of variables that correspond to our seven hypothesis: H1) *General Trust*, H2) *Trusts Farmers in Community*, H3) *Trusts Non-Farmers in Community*, H4) *Trusts Fish and Wildlife Agents*, H5) *Trusts Government Officials*, H6) *Farmer Integrity* and H7) *Trust Index*. A preliminary analysis revealed that farmers who trust one potential social entrepreneur, such as water conservation agents, tend to trust all potential social entrepreneurs. Because of this high correlation, we chose one variable, *Fish and Wildlife Agents,* to represent all potential social entrepreneurs in our analysis. In addition, our preliminary analysis revealed that farmers who trusted their neighbors were highly likely to trust other farmers in their community, so we chose to use *Trusts*

Table 4.1. Variable description and summary statistics

Variable	Description	Exp. Sign	Mean	S.D.	N
Dependent Variables					
Cooperative scouting	Binary variable equal to 1 if respondent indicated a willingness to participate in the cooperative effort (response of 1 or 2 on a 5-point scale): "Cooperate with my neighbors in scouting for pest outbreaks," 0 otherwise		0.69	0.46	225
County-wide crop rotation	Binary variable equal to 1 if respondent indicated a willingness to participate in the cooperative effort (response of 1 or 2 on a 5-point scale): "Participate in a county-wide effort to rotate crops," 0 otherwise		0.36	0.48	225
Coordinate Pesticide Use	Binary variable equal to 1 if respondent indicated a willingness to participate in the cooperative effort (response of 1 or 2 on a 5-point scale): "Coordinate the timing and amount of pesticides I use with my neighbors and/or other local farmers," 0 otherwise		0.54	0.50	225
Trust Variables					
General Trust	Binary variable equal to 1 if respondent indicated that most people could be trusted when asked: "Generally speaking, would you say most people can be trusted or that you need to be very careful in dealing with people.	+	0.61	0.49	229
Trusts Farmers in Community	Binary variable equal to 1 if respondent indicated that farmers in his or her community are usually trustworthy, 0 if respondent indicated that farmers in his or her community were sometimes trustworthy or rarely trustworthy	+	0.72	0.45	219
Trusts Non-Farmers in Community	Binary variable equal to 1 if respondent indicated that non-farmers in his or her community are usually trustworthy, 0 if respondent indicated that non-farmers in the community were sometimes trustworthy or rarely trustworthy	+	0.90	0.30	219
Trusts Fish and Wildlife Agents	Binary variable equal to 1 if respondent indicated that fish and wildlife conservation agents are usually trustworthy, 0 if respondent indicated that wildlife conservation agents were sometimes trustworthy or rarely trustworthy	+	0.88	0.33	222
Trusts Government Officials	Binary variable equal to 1 if respondent indicated that government officials are usually trustworthy, 0 if respondent indicated that government officials in his or her community were sometimes trustworthy or rarely trustworthy	+	0.20	0.40	222
Farmer Integrity	Binary variable equal to 1 if respondent indicated farmers had high integrity after this statement (1 or 2 on a 5-point scale): "Overall, how would you rate the honesty and integrity of farmers?"	+	0.67	0.47	229
Trust Index	Index variable, ranging from 0-12. Respondent received 2 points for each binary trust variable = 1, and 1 point (neutral response) or 0 points (distrust) for each binary trust variable = 0. A score of 12=high trust and a score of 0=low trust.	+	8.03	2.63	212
Other Predictor Variables					
Perceived Benefit 1	Binary variable equal to 1 if respondent agreed with this statement (response of a 1 or 2 on a 5-point scale): "If my neighbors and I worked together, we could manage pests more effectively," 0 otherwise	+	0.68	0.47	223
Perceived Benefit 2	Binary variable equal to 1 if respondent agreed with this statement (response of a 1 or 2 on a 5-point scale): "It would be easier to control pests by crop rotations if most farmers in my county would coordinate their crop rotations," 0 otherwise	+	0.40	0.49	225
Similarity	Binary variable equal to 1 if respondent indicated similarity after this statement (1 or 2 on a 5-point scale): "Think of your nearest 4-5 neighbors. How different or similar to your farm are most of your neighbor's farms or properties," 0 otherwise	+/-	0.68	0.47	228

Social Capital	Binary variable equal to 1 if respondent claimed to be an active member of at least one community organization, 0 if the respondent claimed to be an inactive member or nonmember of all community organizations	+	0.82	0.39	222
Extension Agent Contact	Binary variable equal to 1 if respondent relies on agricultural extension agents for pesticide information; 0 otherwise	+	0.44	0.50	229
Environmental Concern	Count variable from 0-5, indicating number of environmental factors where respondent was highly concerned about pesticide affect, including streams and lakes, bees and other pollinators, pest predator insects, wildlife, and rural drinking water supplies	+	2.61	1.98	220
Control Variables					
Likes to Work in Groups	Binary variable equal to 1 if respondent indicated that given the choice, he or she would rather work in a group to solve a mutual problem; 0 if respondent indicated that he or she would rather work alone	+	0.52	0.50	225
Percent Income from Farming	Binary variable equal to 1 if 75 -100% of the respondent's household income came from farming; 0 otherwise	+	0.47	0.50	227
Farm Sales	Categorical variable representing total farm sales from 2011 where 1 = $10,000 - $50,000, 2= $50,000 - $100,000, 3= $100,000 - $250,000 and 4 = over $250,000				

Valid N (listwise) = 190

Farmers in Community to represent all local farmers in this study, including the farmers' neighbors. Finally, the variable for H7, *Trust Index*, was designed to represent a farmers' overall level of trust and is similar in construction to other trust index variables in the empirical literature that use a number of measures of trust to represent a single trust construct (e.g. Lubell, 2007, Brehm and Rahn, 1997). Our *Trust Index* was constructed by assigning a score of 2, 1 or 0 for each of the other six trust variables. If a respondent indicated trust (binary trust variable = 1), we assigned a score of 2 for that variable. If the respondent did not indicate trust (binary trust variable = 0), we assigned a score of 1 if the respondent indicated neither trust nor distrust and a score of 0 if the respondent indicated distrust. These scores were added together for a total of 12 points possible, where a 12 on our *Trust Index* represents a high level of trust and a 0 represents a low level of trust (Table 4.1).

Our control variables are binary, categorical or continuous variables, constructed from individual survey questions or from a series of related questions (Table 4.1).

Specifically we include five other predictor variables which were identified by Stallman and James (2015) as important determents for farmers' stated willingness to cooperate to control pests, including *Perceived Benefit*, *Environmental Concern*, *Extension Agent Contact*, *Social Capital,* and *Similarity.* The *Extension Agent Contact* variable was designed to be a proxy for positive exposure to agricultural extension agents, while the *Environmental Concern* variable was designed to be a proxy for environmental awareness and concern, especially in regards to the use of pesticides in agriculture. Two of our three control variables, *Farm Sales* and *Percent of Household Income from Farming,* represent farm characteristics that are often important in agricultural adoption studies (Gedikoglu and McCann, 2010; Prokopy et al, 2008) and were identified as potentially meaningful for our study after preliminary analysis using cross tabulations, binary regression models and ordinal regression models. In addition, we include one farmer characteristic variable, *Likes to Work in Groups*, which is often important in teamwork studies in the management and education literatures (e.g. Liu et al., 2007; Shaw et al., 2000).

Likes to Work in Groups represents a farmers' general preference for working with others to solve mutual problems versus a preference for working alone. Sternberg (1997), relates this preference with a person's general cognitive thinking style where internal thinking styles are characterized by introverted, task-oriented thinking and a preference to work alone, and external thinking styles are characterized by extroverted, people-oriented, socially sensitive styles and a preference for collaborating with others (Sternberg, 1977). People who like to work in groups are more likely to seek group work or to join collective activities and are more likely to derive satisfaction from group work, to perform well in groups, and to trust other group members. For example, Liu et al. (2007) found that students with external thinking styles and a preference for group work had a much higher propensity to trust group members when working in teams than those with internal thinking styles who preferred not to work in groups. Shaw et al. (2000) found that employees who prefer group work as opposed to working alone, tend to perform better and derive more satisfaction from group work. And Frege (1996) found that East German union members who preferred to work in groups were more likely to participate in collective action activities than those who preferred to work alone. From this literature base and from this trait's connection to trust, we chose to add the variable, *Likes to Work in Groups*, to our list of controls. In addition, none of our control variables were strongly correlated with each other or with trust (Pearson's $r < 0.5$).

To empirically test how various types of trust may influence a farmer's willingness to participate in cooperative pest control, we specify the following econometric model:

$$WTC = \alpha + X'\beta + Z'\gamma + \varepsilon$$

where WTC is farmers' willingness to cooperate to control pests, α is the intercept, X is a vector of trust variables, β is a vector of parameters to be estimated, Z is a vector of control variables that represent other predictor variables, farm characteristics and farmer characteristics, γ is vector of parameters to be estimated and ε is the error term. Because our dependent variable (WTC) is binary and X and Z are comprised of binary, continuous and categorical variables (Table 1), we estimate this equation by using a binary logistic regression model.

5. Results

Table 4.1 shows the percentage of Missouri crop farmers who exhibit different types of trust. Sixty-one percent of Missouri crop farmers have high general trust and believe that "generally speaking, most people can be trusted." Sixty-seven percent of Missouri crop farmers have trusting beliefs about other farmers, believing that most farmers have a high or very high level of integrity. In addition, most Missouri farmers exhibit relational trust with the other potential participants in cooperative pest control: 72% of farmers believe that other farmers in their community are usually trustworthy, 90% believe that non-farmers in their community are usually trustworthy and 88% believe that fish and wildlife agents are usually trustworthy. In contrast, Missouri crop farmers have low levels of institutional trust. Only 20% believe that government officials in their community are usually trustworthy, while 80% believe that government officials are sometimes trustworthy or never trustworthy. Overall, Missouri farmers are also more trusting than not. They scored an average of 8.03 on our trust index (range 0 - 12), where 12 indicates high trust and 0 indicates low trust.

In order to explore how different types of trust affect farmers' stated willingness to cooperate to control pests, we perform a variety of binary logistic regressions in which the dependent variables are willingness to participate in one of three voluntary cooperative pest control efforts: cooperative scouting for pest outbreaks with neighbors and other local farmers (Table 4.2), coordinating crop rotations on a county-wide scale (Table 4.3), and coordinating the timing and amount of pesticide used with other local farmers (Table 4.4).

Table 4.2
Logit analysis of the effect different types of trust have on farmers' willingness to participate in cooperative scouting.

Variables	Model 1 Trust	Model 2 Controls	Model 3 General Trust	Model 4 Trusts Other Participants	Model 5 Trusts Government	Model 6 Farmer Integrity	Model 7 Trust Index
Perceived Benefit		0.93** (0.43)	0.94** (0.43)	0.95** (0.44)	1.06** (0.47)	0.93** (0.43)	1.08** (0.44)
Extension Agent Contact		1.12*** (0.42).	1.16*** (0.42)	1.21*** (0.43)	1.16*** (0.43)	1.14*** (0.42)	1.53*** (0.43)
Environmental Concern		0.27*** (0.11)	0.27** (0.11)	0.27*** (0.11)	0.25** (0.11)	0.27*** (0.11)	0.27** (0.11)
Similarity to Neighboring Farms		0.10 (0.42)	0.07 (0.42)	-0.03 (0.44)	-0.01 (0.42)	0.08 (0.42)	-0.07 (0.43)
Social Capital		1.11** (0.50)	1.22** (00.51)	1.09** (0.50)	1.14** (0.51)	1.13** (0.50)	1.16** (0.52)
Likes to Work in Groups		2.23*** (0.42)	2.33*** (0.44)	2.44*** (0.45)	2.28*** (0.43)	2.28*** (0.45)	2.40*** (0.45)
Percent Income from Farming > 75%		0.82* (0.46)	0.84* (0.46)	0.76 (0.47)	0.78* (0.47)	0.83* (0.46)	0.74 (0.46)
Farm Sales ($10,000-50,000)		-1.07* (0.64)	-1.04* (0.64)	-1.11* (0.65)	-0.95 (0.65)	-1.12* (0.65)	-1.03 (0.64)
Farm Sales ($51,000-100,000)		-0.76 (0.64)	-0.72 (0.64)	-0.87 (0.65)	-0.81 (0.65)	-0.80 (0.65)	-0.80 (0.65)
Farm Sales ($101,000-250,000)		-1.28** (0.60)	-1.26** (0.60)	-1.27** (0.61)	-1.24** (0.61)	-1.31** (0.61)	-1.24 (0.61)
General Trust	0.37 (0.29)		-0.47 (0.41)				
Trusts Farmers in Community	0.31 (0.36)			0.33 (0.50)			
Trusts Non-Farmers in Community	0.06 (0.48)			-1.32* (0.75)			
Trusts Fish and Wildlife Agents	0.15 (0.29)			0.06 (0.41)			
Trusts Government Officials	-0.31 (0.35)				-0.65 (0.53)		
Farmer Integrity	0.58** (0.30)					-0.17 (0.43)	
Trust Index	0.04 (0.05)						-0.12 (0.08)

Intercept	-2.52 (0.87)	-2.40 (0.88)	-1.58 (1.02)	-2.42 (0.88)	-2.43 (0.90)	-1.58 (1.00)
Psuedo - R-square	0.46	0.46	0.47	0.47	0.46	0.46
-2 Log Likelihood	167.78	166.45	159.69	162.32	167.63	160.54
Chi-Square (df) for variables in model	79.11 (10)***	80.44 (11)***	80.35 (13)***	79.99 (11)***	79.26 (11)***	77.95 (11)***
% WTP Correctly Predicted	82.9%	82.9%	83.9%	82.6%	82.9%	82.8%
Number of Observations	199	199	192	195	199	192

Note: For Model 1, each trust variable was run separately in a model that only included the independent variable trust. Standard Errors are in parentheses. The excluded Farm Sales Category is Farm Sales > $250,000. * Significant at 10%, ** Significant at 5%, ***Significant at 1%

Table 4.3

Logit analysis of the effect different types of trust have on farmers' willingness to coordinate crop rotations on a county-wide scale.

Variables	Model 1 Trust	Model 2 Controls	Model 3 General Trust	Model 4 Trusts Other Participants	Model 5 Trusts Government	Model 6 Farmer Integrity	Model 7 Trust Index
Perceived Benefit		1.19*** (0.33)	1.19*** (0.33)	1.21*** (0.35)	1.29*** (0.34)	1.18*** (0.33)	1.24*** (0.34)
Extension Agent Contact		0.48 (0.33)	0.51 (0.33)	0.78** (0.35)	0.62* (0.34)	0.47 (0.33)	0.64* (0.34)
Environmental Concern		0.16* (0.09)	0.16* (0.09)	0.17* (0.09)	0.15* (0.09)	0.15* (0.09)	0.16* (0.09)
Similarity to Neighboring Farms		-0.43 (0.36)	-0.45 (0.37)	-0.58 (0.38)	-0.49 (0.37)	-0.42 (0.36)	-0.53 (0.37)
Social Capital		0.05 (0.45)	0.09 (0.45)	0.02 (0.47)	0.07 (0.46)	0.24 (0.45)	0.06 (0.46)
Likes to Work in Groups		1.01*** (0.35)	1.07 (0.36)	1.21*** (0.37)	1.04*** (0.36)	0.96*** (0.36)	1.13*** (0.37)
Percent Income from Farming		-0.25 (038)	-0.25 (0.38)	-0.35 (0.40)	-0.24 (0.39)	-0.24 (0.38)	-0.24 (0.39)
Farm Sales ($10,000-$50,000)		-0.44 (0.50)	-0.44 (0.50)	-0.24 (0.53)	-0.24 (0.52)	-0.38 (0.52)	-0.29 (0.52)

Farm Sales ($51,000-$100,000)		-0.10 (0.53)	-0.08 (0.53)	-0.24 (0.55)	-0.18 (0.55)	-0.07 (0.54)	-0.21 (0.54)
Farm Sales ($101,000-$250,000		0.00 (0.47)	-0.01 (0.47)	0.04 (0.49)	0.04 (0.48)	0.02 (0.47)	-0.03 (0.48)
General Trust	0.32 (0.29)		-0.23 (0.36)				
Trusts Farmers in Community	0.31 (0.32)			-0.03 (0.40)			
Trusts Non-Farmers in Community	-0.42 (0.45)			-0.84 (0.61)			
Trusts Fish and Wildlife Agents	-0.16 (0.28)			-0.45 (0.53)			
Trusts Government Officials	-0.04 (0.34)				-0.36 (0.42)		
Farmer Integrity	0.67** (0.31)					0.21 (0.37)	
Trust Index	0.06 (0.04)						-0.05 (0.07)
Intercept			-1.86 (0.73)	-0.75 (0.90)	-1.98 (0.74)	-2.05 (0.37)	-1.62 (0.87)
Psuedo - R-square			0.22	0.27	0.24	0.22	0.25
-2 Log Likelihood			222.80	209.27	215.20	222.90	212.54
Chi-Square (df) for variables in model			36.17 (11)***	42.38 (13)***	39.08 (11)***	36.07 (11)***	39.12 (11)***
% WTP Correctly Predicted			72.5%	72.0%	69.9%	72.0%	73.1%
# of Observations			200	193	196	200	193

Note: For Model 1, each trust variable was run separately in a model that only included the independent variable trust. Standard Errors are in parentheses. The excluded Farm Sales Category is Farm Sales > $250,000. * Significant at 10%, ** Significant at 5%, ***Significant at 1%

Table 4.4
Logit analysis of the affect different types of trust have on farmers' willingness to coordinate pesticide use with other local farmers.

Variables	Model 1 Trust	Model 2 Controls	Model 3 General Trust	Model 4 Trusts Other Participants	Model 5 Trusts Government	Model 6 Farmer Integrity	Model 7 Trust Index
Perceived Benefit		1.09*** (0.39)	1.09*** (0.39)	1.22*** (0.41)	1.21*** (0.40)	1.10*** (0.40)	1.21*** (0.41)
Extension Agent Contact		0.73** (0.35)	0.72** (0.35)	0.64* (0.36)	0.70* (0.36)	0.76** (0.35)	0.70** (0.36)
Environmental Concern		0.43*** (0.10)	0.44*** (0.10)	0.45*** (0.10)	0.42*** (0.10)	0.43*** (0.10)	0.44*** (0.10)
Similarity to Neighboring Farms		0.54 (0.38)	0.54 (0.38)	0.39 (0.39)	0.48 (0.38)	0.51 (0.38)	0.37 (0.39)
Social Capital		0.52 (0.46)	0.48 (0.47)	0.48 (0.49)	0.56 (0.47)	0.54 (0.47)	0.50 (0.48)
Likes to Work in Groups		1.36*** (0.36)	1.32*** (0.37)	1.40*** (0.37)	1.37*** (0.37)	1.42*** (0.38)	1.44*** (0.38)
Percent Income from Farming		0.46 (0.40)	0.45 (0.40)	0.36 (0.41)	0.40 (0.41)	0.45 (0.40)	0.34 (0.41)
Farm Sales ($10,000-$50,000)		-1.26** (0.55)	-1.27** (0.55)	-1.31** (0.56)	-1.27** (0.56)	-1.33** (0.56)	-1.32** (0.56)
Farm Sales ($51,000-$100,000)		-0.66 (0.56)	-0.69 (0.57)	-0.62 (0.57)	-0.59 (0.57)	-0.72 (0.57)	-0.62 (0.57)
Farm Sales ($101,000-250,000)		-0.59 (0.53)	-0.60 (0.53)	-0.62 (0.54)	-0.55 (0.53)	-0.62 (0.53)	-0.63 (0.54)
General Trust	0.58*** (0.27)		0.16 (0.36)				
Trusts Farmers in Community	0.53* (0.30)			-0.02 (0.42)			
Trusts Non-Farmers in Community	0.58 (0.45)			0.28 (0.69)			
Trusts Fish and Wildlife Agents	0.05 (0.27)			-0.23 (0.37)			
Trusts Government Officials	-0.26 (0.33)				-0.39 (0.45)		
Farmer Integrity	0.34 (0.28)					-0.25 (0.38)	

Trust Index	0.07* (0.04)						-0.04 (0.08)
Intercept		-3.23 (0.83)	-3.27 (0.83)	-3.26 (1.07)	-3.17 (0.84)	-3.09 (0.86)	-2.83 (0.95)
Psuedo - R-square		0.39	0.39	0.40	0.39	0.39	0.40
-2 Log Likelihood		205.12	204.91	195.54	199.88	204.69	195.82
Chi-Square (df) for variables in model		68.63 (10)***	68.84 (11)***	68.35 (13)***	68.31 (11)***	69.06 (11)***	68.07 (11)***
% WTP Correctly Predicted		71.7%	73.2%	72.8%	71.1%	71.7%	73.8%
Number of Observations		198	198	191	194	198	191

Note: For Model 1, each trust variable was run separately in a model that only included the independent variable, trust. Standard Errors are in parentheses. The excluded Farm Sales Category is Farm Sales > $250,000. * Significant at 10%, ** Significant at 5%, ***Significant at 1%

We begin our analysis with regressions for each of our three dependent variables, where each trust variable was run separately in a model that only included the independent variable, trust. For conciseness, we present coefficients for the seven separate regressions in a single column in Tables 4.2, 4.3 and 4.4 labeled Model 1. Our Model 1 regressions on *Cooperative Scouting* and *Coordinate Pesticide Use* show that all of our trust variables are positively correlated with Missouri farmers' stated WTC to control pests, except for *Trusts Government Officials*, which is negatively correlated to WTC (Tables 4.2 and 4.4). In addition, four of our trust variables, *General Trust*, *Trusts Farmers in Community*, *Farmer Integrity,* and *Trust Index* are significant in at least one Model 1 regression (Table 4.4). Our Model 1 regression on *County-wide Crop Rotations*, however, tells a different story. Only, one variable, *Farmer Integrity* is positively and significantly correlated to WTC, and three variables, *Trusts Non-Farmers in Community*, *Trusts Fish and Wildlife Agents* and *Trusts Government Officials* are negatively correlated to WTC (Table 4.3). These results suggest that some types of trust may be important, and that the effect trust has on farmers' stated willingness to cooperate to control pests varies with the cooperative activity.

In Model 2 of Tables 4.2, 4.3 and 4.4, we run a series of regressions that include our eight control variables, but not our trust variables. Again, our regressions on *Cooperative Scouting* and *Coordinate Pesticide Use* are similar, but not identical. All coefficients have the expected sign, and all control variables, except *Similarity*, behave as expected and are significantly correlated with WTC in most models (Tables 4.2 and 4.4). Our regressions on *County-wide Crop Rotations*, however, again tells a different story (Table 4.3). Only the coefficients for *Perceived Benefit, Environmental Concern*, and *Likes to Work in Groups* behave as expected. The coefficients for *Similarity to Neighboring Farms* and *Percent Income from Farming* are neither significant, nor do they carry the expected sign (Table 4.3). These results confirm and add to the results from Stallman and James (2015). In addition, the coefficients for our control variable, *Likes to Work in Groups*, are positive, highly significant, and 1.5 - 3 times larger than the coefficients for all the other dichotomous control variables (Tables 4.2 – 4.4).

In Models 3 – 7, we add the variables for different types of trust. Each model includes one trust variable plus the control variables, except for Model 5 which includes three types of relational trust, *Trusts Farmers in Community, Trusts Non-Farmers in Community* and *Trusts Fish and Wildlife Agents*. None of the coefficients for the trust variables that are significant in Model 1 are still significant in the models that include control variables. Plus, the coefficients for three variables that were positive and significant in Model 1, switch signs and are negative, but not significant, in the models that include different types of trust: *Trust Farmers in Community* and *Trust Index* for

WTC to *Coordinate Pesticide Use*, and *Farmer Integrity* for WTC in *Cooperative Scouting* (Tables 4.2 and 4.4). In addition, many of the coefficients for trust variables that are positively correlated to WTC in Model 1, switch signs and are negatively correlated to WTC in Models 3 -7 (Tables 4.2 – 4.4). Finally, one variable whose coefficient was positive in Model 1, *Trusts Non-Farmers in Community*, switch signs and is negative and significant in the regression for WTC in *Cooperative Scouting* (Table 4.2).

Finally, our analysis includes interactions between our trust variables and the two control variables that are often linked to trust in the literature: similarity and likes to work in groups. Although we contend that trust, similarity between actors, and a preference for working in groups are three separate constructs, it is possible that trust may only become important for farmers' WTC under certain conditions, such as when neighboring farms are dissimilar. To check for interaction effects, we ran a series of regressions that included our trust variables, our control variables, and the interaction term for *Trust* by *Similarity* or the interaction term for *Trust* by *Likes to Work in Groups* (Tables 4.5 and 4.6).

The coefficient for the interaction term for *Trusts Farmers in Community* by *Similarity* is significant for WTC in *Cooperative Scouting* and *Coordinate Pesticide Use* (Table 4.5). Thus, farmers' whose farms are dissimilar from neighboring farms are significantly more willing to cooperate if they trust other farmers in their community than if they do not. However, farmers' level of trust in other farmers does not matter if their farms are similar. In other words, trust may become important under the condition of heterogeneity. In addition, the coefficients for the interaction terms for *Trusts Non-*

Table 4.5: Coefficients for Trust, Similarity, and their interaction effects for different kinds of trust in alternate specifications of the WTC regressions.

Trust Variable	Trust	Similarity to Neighboring Farms	Trust by Similarity	Pseudo r-square	N
WTC Cooperative Scouting					
General Trust	-1.32	-0.74	1.30	0.48	199
Trusts Farmers in Community	1.47*	1.74*	-1.91*	0.51	192
Trusts Non-Farmers in Community	-1.80	-1.37	-1.80	0.50	193
Trusts Fish and Wildlife Agents	-2.40*	-0.55	1.53	0.49	197
Trusts Government Officials	-0.72	-0.03	0.11	0.47	195
Farmer Integrity	-0.04	0.19	-0.19	0.46	199
Trust Index	-0.10	0.13	-0.02	0.47	191
WTC Coordinate Crop Rotations					
General Trust	-0.15	-0.37	-0.12	0.22	200
Trusts Farmers in Community	-0.23	-0.73	0.25	0.27	196
Trusts Non-Farmers in Community	0.64	1.06	-1.73	0.29	194
Trusts Fish and Wildlife Agents	-1.58*	-0.92	0.42	0.27	196
Trusts Government Officials	-0.24	-0.44	-0.21	0.24	196
Farmer Integrity	-0.10	-0.77	0.51	0.23	200
Trust Index	-0.50	-0.02	-0.01	0.25	192
WTC Coordinate Pesticide Use					
General Trust	-0.25	0.15	0.62	0.39	198
Trusts Farmers in Community	1.05	1.64**	-1.61*	0.41	194
Trusts Non-Farmers in Community	-0.08	0.06	0.38	0.40	192
Trusts Fish and Wildlife Agents	-1.70*	-0.21	0.90	0.41	196
Trusts Government Officials	0.07	0.63	-0.73	0.39	194
Farmer Integrity	-0.19	0.57	-0.09	0.39	198
Trust Index	0.00	1.17	-0.07	0.40	190

Note: Each regression include the same control variables as reported in Model 2 in Tables 2, 3 and 4.
 * Significant at 10%, ** Significant at 5%, ***Significant at 1%

Farmers in Community and *General Trust* are significant for WTC to *Coordinate Pesticide Use* (Table 4.6). Thus, a farmers' level of general trust or trust in non-farmers in the community seem to only be important to farmers who do not like to work in groups. These types of trust do not seem to matter to farmers who prefer group work.

Results from our initial analysis suggest that our trust variables may be endogenous, so we also run a series of 2-stage regressions to control for endogeneity and to further explore the effect different types of trust have on farmers' stated WTC to control pests. We estimate the first stage by using an ordinary least squares model (see

Table 4.6: Coefficients for Trust, Group, and their interaction effects for different kinds of trust in alternate specifications of the willingness to cooperate regressions.

Trust Variable	Trust Variable	Group	Trust by Group	Pseudo R-Square	N
WTC Cooperative Scouting					
General Trust	-0.12	3.01***	-1.03	0.47	199
Trusts Farmers in Community	-0.13	1.54*	1.06	0.50	196
Trusts Non-Farmers in Community	Convergence	Error			
Trusts Fish and Wildlife Agents	Convergence	Error			
Trusts Government Officials	0.04	2.67***	-1.54	0.48	195
Farmer Integrity	0.10	2.81***	-0.78	0.46	199
Trust Index	-0.07	4.18***	-0.15	0.47	191
WTC Coordinated Crop Rotations					
General Trust	-0.25	1.10**	-0.03	0.17	199
Trusts Farmers in Community	0.17	1.54**	-0.68	0.18	195
Trusts Non-Farmers in Community	-1.18*	0.60	0.62	0.20	193
Trusts Fish and Wildlife Agents	-1.34*	0.32	0.78	0.19	197
Trusts Government Officials	-0.44	1.05***	-0.08	0.18	195
Farmer Integrity	0.32	1.10*	-0.21	0.17	199
Trust Index	-0.05	1.04	0.01	0.19	191
WTC Coordinated Pesticide Use					
General Trust	0.81	2.12***	-1.29*	0.40	198
Trusts Farmers in Community	0.65	2.27***	-1.14	0.41	194
Trusts Non-Farmers in Community	-0.99	-1.91	3.64***	0.43	192
Trusts Fish and Wildlife Agents	-1.84**	0.01	1.58	0.41	196
Trusts Government Officials	0.44	1.71***	-1.40	0.40	194
Farmer Integrity	0.18	2.02***	-0.91	0.40	198
Trust Index	-0.01	2.20*	-0.06	0.40	190

Note: Each regression includes the same control variables as reported in Model 2 in Tables 2, 3 and 4. Convergence Error signifies that the model failed to converge. * Significant at 10%, ** Significant at 5%, ***Significant at 1%

for justification). We chose two variables as our instrument, *High School* and *Information*. *High School* is a dichotomous variable that is equal to 1 if the respondent has a high school education or above, and equal to 0 otherwise. *Information* is a dichotomous variable equal to 1 if the respondent gets pest control information from friends and neighbors, and equal to 0 otherwise. The second stage in our 2-stage regression is estimated by using a binary logistic regression model.

In the first stage of our 2-stage analysis, we estimate predicted values for our trust variables in a series of regressions in which our dependent variables are our trust variables and our independent variables are our control variables plus an instrument that includes the variables, *High School* and *Information* (Table 4.7). In the second stage, we run a series of regressions in which our dependent variables are our WTC variables and our independent variables are our control variables and the predicted values for the trust variables from stage 1 (Tables 4.8 - 4.10).

Our stage-1 F-values are quite low, suggesting difficulty in modeling trust (Table 4.7). The coefficients for the variables in our instrument are only weakly significant for most of our trust variables, and neither one is significant for *Trusts Non-Farmers in Community* (Table 4.7). For this reason, and because of its low F-value and some non-convergence issues, we chose to leave the variable, *Trusts Non-Farmers in Community*, out of the 2-stage analysis (Tables 4.8 – 4.10). Only a few of our control variables are significant in stage 1 of our analysis. *Extension Agent Contact* and *Likes to Work in Groups* are significant for four trust variables, and *Environmental Concern, Social Capital and Farm Sales* are significant for one trust variable each (Table 4.7).

Our 2-stage analysis results are given in Tables 4.8 – 4.10. We do not include standard errors or significance values for our 2nd-stage coefficients because the standard errors are biased in this type of analysis. We can, however, compare the signs and magnitude of our coefficients to get some indication of how different types of trust affect farmers' stated WTC to control pests. Three interesting trends are evident from this analysis. First, all of the trust variables are positively correlated to our WTC variables in Model 1 before the control variables are added, as expected (Tables 4.8 – 4.10). Second,

Table 4.7: Stage 1 OLS analysis for the Trust Variables.

Variables	General Trust	Trusts Farmers in Community	Trusts Non-Farmers in Community	Trusts Fish and Wildlife Agents	Trusts Government Officials	Farmer Integrity	Trust Index
Perceived Benefit	-0.05 (0.07)	0.11 (0.07)	0.02 (0.04)	0.91 (0.21)	0.06 (0.07)	0.05 (0.07)	0.23 (0.41)
Extension Agent Contact	0.13* (0.07)	0.03 (0.07)	0.10** (0.04)	-0.03 (0.07)	0.13** (0.06)	0.08 (0.06)	0.83** (0.37)
Environmental Concern	-0.00 (0.02)	0.01 (0.02)	-0.00 (0.01)	0.03* (0.02)	-0.02 (0.02)	0.00 (0.02)	0.05 (0.09)
Similarity to Neighboring Farms	-0.10 (0.07)	0.02 (0.07)	-0.04 (0.05)	0.07 (0.08)	-0.05 (0.06)	-0.07 (0.07)	-0.40 (0.38)
Social Capital	0.11 (0.09)	0.22** (0.09)	0.02 (0.06)	-0.10 (0.10)	0.05 (0.08)	0.12 (0.09)	0.43 (0.49)
Likes to Work in Groups	0.24*** (0.07)	0.06 (0.07)	0.08 (0.04)*	0.11 (0.07)	0.00 (0.06)	0.26*** (0.07)	1.24*** (0.37)
Percent Income from Farming	-0.06 (0.08)	-0.00 (0.075)	-0.06 (0.05)	-0.12 (0.08)	-0.10 (0.07)	-0.02 (0.08)	-0.56 (0.41)
Farm Sales ($10,000 - $50,000)	-0.06 (0.10)	-0.05 (0.10)	0.04 (0.07)	-0.03 (0.11)	0.09 (0.09)	-0.27*** (0.10)	-0.42 (0.56)
Farm Sales ($51,000 - $100,000)	0.07 (0.11)	0.05 (0.10)	-0.01 (0.07)	-0.14 (0.11)	-0.32 (0.09)	-0.16 (-0.12)	-0.37 (0.58)
Farm Sales ($101,000-250,000)	-0.06 (0.09)	-0.03 (0.09)	0.04 (0.06)	0.06 (0.10)	0.10 (0.08)	-0.11 (0.09)	0.25 (0.51)
High School Diploma or Higher Education	-0.24 (0.13)*	-0.19* (0.13)	0.11 (0.09)	-0.39*** (0.14)	-0.23* (0.12)	0.19* (0.13)	-1.59** (0.75)
Asks Friends and Neighbors for Pesticide Information	0.14 (0.07)**	0.04 (0.07)	0.02 (0.04)	-0.07 (0.07)	-0.04 (0.06)	0.06 (0.07)	0.45 (0.48)
Intercept	0.63 (0.20)	0.55 (019)	0.72 (0.13)	0.91 (0.22)	0.40 (0.18)	0.31 (0.20)	8.29 (1.10)
R-square	0.16	0.10	.10	0.12	0.12	0.17	0.17
F-value	2.81	1.56	1.54	2.03	1.94	3.10	3.01
# of Observations	196	192	190	194	192	196	189

Note: Standard Errors are in parentheses. The excluded Farm Sales Category is Farm Sales > $250,000.
* Significant at 10%, ** Significant at 5%, ***Significant at 1%

Table 4.8
2-stage logit analysis of the affect different trust types have on farmers' WTC in cooperative scouting.

Variables	Model 1 Trust Variables	Model 2 General Trust	Model 3 Trusts other Participants	Model 4 Trusts Government	Model 5 Farmer Integrity	Model 6 Trust Index
Perceived Benefit		0.99	0.79	0.94	0.98	0.92
Extension Agent Contact		0.98	1.00	0.99	1.07	0.93
Environmental Concern		0.27	0.27	0.28	0.27	0.26
Similarity to Neighboring Farms		0.19	0.06	0.15	0.11	0.19
Social Capital		1.08	0.73	1.17	1.23	1.09
Likes to Work in Groups		2.01	2.11	2.17	2.25	2.00
Percent Income from Farming		0.90	0.82	0.91	0.87	0.94
Farm Sales Cat. 1 ($10,000 - $50,000)		-0.96	-0.92	-1.02	-1.06	-0.93
Farm Sales Cat. 2 ($51,000 - $100,000)		-0.67	-0.78	-0.61	-0.67	-0.57
Farm Sales Cat. 3 ($101,000 - 250,000)		-1.15	-1.12	-1.23	-1.59	-1.24
General Trust	4.90	0.66				
Trusts Farmers in Community	7.01		1.71			
Trusts Fish and Wildlife Agents	1.86		-0.39			
Trusts Government Officials	1.38			0.41		
Farmer Integrity	5.91				-0.29	
Trust Index	0.86					0.12
Intercept		-2.96	-3.09			
Psuedo - R-square		0.46	0.46	0.45	0.45	0.45
% WTP Correctly Predicted		82.1%	82.1%	82.7%	82.7%	82.7%
Number of Observations		196	196	196	196	196

Note: For Model 1, each trust variable was run separately in a model that only included the independent variable, trust. Standard Errors are in parenthesis and are only included for Model 2, which does not include stage 1 variables. The excluded Farm Sales Category is Farm Sales > $250,000. * Significant at 10%, ** Significant at 5%, ***Significant at 1%

Table 4.9

2-Stage logit analysis of the affect different types of trust have on farmers' willingness to coordinate crop rotations on a county-wide scale.

Variables	Model 1 Trust	Model 2 General Trust	Model 3 Trusts other Participants	Model 4 Trusts Government	Model 5 Farmer Integrity	Model 6 Trust Index
Perceived Benefit		1.22	1.24	1.29	1.23	1.25
Extension Agent Contact		0.60	0.31	0.82	0.11	0.66
Environmental Concern		0.12	0.20	0.08	0.09	0.13
Similarity to Neighboring Farms		-0.46	0.84	-0.55	-0.03	-0.47
Social Capital		0.04	1.68	0.03	-0.78	0.03
Likes to Work in Groups		1.21	-0.78	1.03	-0.42	1.24
Percent Income from Farming		-0.31	-0.23	-0.48	-0.15	-0.37
Farm Sales Cat. 1 ($10,000 - $50,000)		-0.52	-0.98	-0.25	1.19	-0.53
Farm Sales Cat. 2 ($51,000 - $100,000)		-0.12	0.36	-0.19	0.80	-0.22
Farm Sales Cat. 3 ($101,000 - $250,00)		-0.13	-4.11	0.14	0.62	-0.04
General Trust	2.18	-0.74				
Trusts Farmers in Community	2.70		4.69			
Trusts Fish and Wildlife Agents	1.56		-4.11			
Trusts Government Officials	1.05			-2.00		
Farmer Integrity	3.05				5.39	
Trust Index	0.44					-0.17
Intercept		-1.44	-1.49	-1.35	-4.70	-0.56
Psuedo - R-square		0.22	0.24	0.23	0.24	0.22
% WTP Correctly Predicted		71.4%	70.9%	72.4%	72.4%	71.4%
# of Observations		196	196	196	196	196

Note: For Model 1, each trust variable was run separately in a model that only included the independent variable, trust. The excluded Farm Sales Category is Farm Sales > $250,000. * Significant at 10%, ** Significant at 5%, ***Significant at 1%

Table 4.10

2-stage logit analysis of the affect different types of trust have on farmers' willingness to coordinate pesticide use with local farmers.

Variables	Model 1 Trust	Model 2 General Trust	Model 3 Trusts Other Participants	Model 4 Trusts Government	Model 5 Farmer Integrity	Model 6 Trust Index
Perceived Benefit		1.12	1.14	0.93	1.27	1.05
Extension Agent Contact		0.78	0.88	0.41	1.03	0.64
Environmental Concern		0.42	0.36	0.49	0.43	0.41
Similarity to Neighboring Farms		0.59	0.78	0.72	0.35	0.64
Social Capital		0.39	1.04	0.29	0.80	0.29
Likes to Work in Groups		1.35	1.31	1.45	2.27	1.17
Percent Income from Farming		0.44	0,69	0.68	0.34	0.53
Farm Sales Cat. 1 ($10,000 - $50,000)		-1.38	-1.51	-1.74	-2.35	-1.36
Farm Sales Cat. 2 ($51,000 - $100,000)		-0.79	-0.40	-0.74	-1.34	-0.71
Farm Sales Cat. 3 ($101,000 - $250,000)		-0.69	-0.96	-1.06	-1.13	-0-80
General Trust	2.78	0.31				
Trusts Farmers in Community	5.52		-1.60			
Trusts Fish and Wildlife Agents	2.47		2.24			
Trusts Government Officials	0.70			2.72		
Farmer Integrity	4.16				-3.06	
Trust Index	0.63					0.21
Intercept		-3.21	-3.61	-3.50	-1.46	-4.53
Psuedo - R-square		0.39	0.40	0.40	0.40	0.39
% WTP Correctly Predicted		72.8%	72.3%	72.8%	72.8%	72.8%
Number of Observations		195	195	195	195	195

Note: For Model 1, each trust variable was run separately in a model that only included the independent variable, trust. The excluded Farm Sales Category is Farm Sales > $250,000. * Significant at 10%, ** Significant at 5%, ***Significant at 1%

many coefficients for the trust variables switch signs in Models 2-6 (Tables 4.8 – 4.10), similar to our 1-stage binary logistic regression Models 3-7 (Tables 4.2 - 4.4). Finally, the coefficients for a few of our control variables that did not significantly affect trust in the first stage of our analysis (i.e. *Perceived Benefit*) remain fairly consistent in magnitude and have the same sign in Models 2-6 for all three WTC variables. However, the coefficients for most of our control variables, especially those that significantly correlated to trust in the first stage of the analysis and those that occur in the models for *County-wide Crop Rotations*, are inconsistent in magnitude and occasionally switch signs in Models 2-6. These results suggest that our 2-stage analysis either failed to control for endogeneity, or that endogeneity was not the problem in our original analysis.

6. Discussion

The provision of the ES, pest control, in agricultural ecosystems is important for the long-term sustainability of crop production in the United States (Bianchi et al., 2006). Many scholars believe that natural pest control should be managed at the landscape level and must include a cooperative effort between landowners to be effective (e.g. Cummings and Spiesman, 2006). Trust facilitates cooperation between farmers in traditional agricultural cooperatives, as well as in collaborative natural resource management initiatives (Lundqvist, 2001; Marshall, 2004). Little is known, however, about how trust affects farmers' willingness to cooperate to provide an ES, such as natural pest control, what types of trust are most important, and under what conditions trust may matter. This study fills this research gap by exploring the role of trust in farmers willingness to cooperate to control pests.

Consistent with the empirical literature, we find that most farmers in our study indicate that they have a moderate to high level of trust (e.g. Roe et al., 2014) (Table 4.1). A high percentage of farmers indicate that they trust other farmers in their community, non-farmers in their community, and potential social entrepreneurs, such as soil conservation agents and agricultural extension agents. In fact, the only community members farmers seem unwilling to trust are government officials. More than half of farmers also believe that most people can be trusted and that other farmers have a high level of integrity. The social sciences literature is full of support for the hypothesis that trust, such as that demonstrated by the farmers in our study, fosters cooperation between actors (e.g. Hardin, 2002). Our analysis, however, presents a more cautious view. In particular, we find little support for our hypothesis that trust is important in farmers' stated willingness to cooperate to control pests.

Numerous scholars have found that different trust types have different effects on the outcome of social or economic interactions (Zaheer et al., 2008; Zhu et al., 2013; Stern, 2010). However, our analysis only weakly supports this hypothesis. Four types of trust (general trust, trust in potential participants, trusting beliefs and overall trust) are positively correlated with the farmers' stated willingness to cooperate to control pests, while one type (trust in government officials) is negatively correlated. In addition, we found weak evidence that trust does not have the same effect on each cooperative activity. The coefficients for our trust variables vary in sign and magnitude for each of the three types of cooperative pest control activities . Finally, the only trust variables that are significant when the controls are in the models are some of the interaction terms, suggesting that trust is only important for farmers' WTC under certain conditions, such as when neighboring farms are dissimilar.

Our analysis also provides some evidence that some of the effects of trust are being captured by other variables in the model. For example, the variable *Extension Agent Contact* is significant when we model for trust in our 2-stage regression. *Extension Agent Contact* is a proxy for positive interaction with agricultural extension agents, whose importance for farmers' stated WTC to control pests is predicted by the agricultural adoption literature and the ecosystem management literature (e.g. Gedikoglu and McCann, 2010; Wondolleck and Yaffee, 2000), and is documented by Stallman and James (2015). For this study, we defined positive interaction with agricultural extension agents as a farmer receiving pest control information from agricultural extension agents. This proxy not only captures access to extension agents and positive experiences with extension agents, it also likely captures some level of trust since a farmer's reliance on someone else for advice that could affect her crop yields by definition implies some level of trust. Likewise, our variable, *Likes to Work in Groups*, is often associated with higher levels of personal trust in the literature (e.g. Liu et al., 2007) and may have captured some of the effect of trust in our model.

Not only was trust as an individual construct unimportant to farmers who are considering cooperation to control pests, we find that trust is much less important to farmers' WTC cooperate than other considerations. All of our control variables were more important than trust in farmers' willingness to cooperate, including whether or not farmers 1) believe that they will receive a benefit from cooperating, 2) receive pest control information from agricultural extension agents, 3) are highly concerned about the affect pesticides may have on the environment, 4) prefer to work in groups, 5) make most of their income from farming, 5) have relatively large farm sales, and 6) are an active member of at least one community organization. To put this in context, we can compare the coefficients of our dichotomous variables to determine relative importance of the variable. For example, *Perceived Benefit* and *Percent Income* are twice as important as *General Trust* to farmers' WTC in cooperative scouting, *Extension Agent Contact* and *Social Capital* are about three times more important than *General Trust*, and *Likes to Work in Groups* is five times more important than *General Trust* (Table 4.2). In fact, the control variable, *Likes to Work in Groups*, which has rarely been considered in the collective action literature, may be the most important determinant in farmers' stated willingness to cooperate to control pests. This variable is consistently about 3 - 5 times more important than the trust variables, and about 1.5 - 3 times more important than the other dichotomous control variables (Tables 4.2, 4.3 and 4.4).

Most scholars believe that trusting others can be a rational decision where the trustor assesses the costs and benefits of trusting others before making the decision to trust (e.g. Castelfranchi and Falcone, 2000). We did not include rational trust as a trust type in this study because we believe its affect is partially captured by other variables in our model, such as perceived benefit. More research, however, is needed to determine the specific costs and benefits of cooperating to control pests and how those costs and benefits affect farmers' willingness to cooperate. For example, net benefits may differ by crop grown; farm size or land tenure; institutional factors; the farms' location in the landscape or cooperative; organizational characteristics of the cooperative; producer characteristics, such as risk-adversity and time spent on managerial activities; and resource characteristics, such as soil biodiversity, and these characteristics' interactions with pest populations and pest-predator populations (Ostrom, 1990, 2001; Lubell et al., 2002; Lubell, 2004; Fernandez-Cornejo, et al., 1994; Cong et al., 2014a; Cong et al, 2014b). More research is needed to determine how net benefits, including unequal net benefits for providers, may affect farmers' WTC to control pests.

More research is also needed to further explore the possible interactions we discovered between trust and similarity, and trust and a farmer's preference for group work. Plus, more research is needed on context-specific trust. Many scholars believe that trust must be understood within the context of specific domains or specific cooperative activities, including scholars studying trust within the context of collaborative natural resource management (e.g. Lubell, 2007; Nannestad, 2008). In other words, specific trustors may be willing to depend on a specific trustees with respect to specific events or under specific circumstances. Our study explored trustors and trustees, but we did not specify domains or contexts for trust. In fact, the variable that could be considered our most domain-specific measurement of trust (do farmers rely on agricultural extension agents for pest control information) was not considered a trust variable in this study. However, it proved to be the more useful concept when determining what factors affect farmers' WTC to control pests. Future research into the role trust in cooperative pest control should concentrate on specific contexts for trust and on more concrete concepts of trust, such as our *Agricultural Extension* variable. For example, we need to ask in what specific contexts and under what conditions do farmers find their neighbors' trustworthy, competent or benevolent?

This study is important because we determine that trust as an individual construct does not seem important in a farmer's willingness to cooperate to control pests. By addressing a form of cooperative pest control that has not been previously considered in the literature, we both confirm and add to the results of Stallman and James (2015) who determined that not all cooperative pest control activities should be treated alike. We also provide evidence that trust may only be important under certain conditions, such as when farms are dissimilar, and that other determinants, such as concern for environment and perceived benefit, are more important than trust to farmers who are considering cooperation to control pests. In addition, this study provides strong evidence that a farmers' preference for group work to solve mutual problems, versus working alone, is important in their willingness to cooperate to control pests--an important determinant that may affect collective action in other situations.

7. Conclusion

In this study, we fill a gap in the literature by answering three important questions about the role of trust in cooperative pest control: 1) is trust an important determinant in a farmers' stated willingness to cooperate to control pests? 2) do different types of trust have different affect farmers' willingness to cooperate to control pests, and 3) under what conditions may trust matter to farmers who are considering participation in cooperative pest control? Although trust is often touted as an important element in cooperation (e.g. Hardin, 2002), we find little evidence to support our hypothesis that trust as an individual construct is important to a farmers' stated willingness to cooperate to control pests. In fact, all of our control variables were more important determinants for willingness to cooperate, including a preference for working in groups, which has rarely been considered in the collective action literature.

Trust is a nebulous bundle of ideas and concepts that is defined and operationalized in numerous ways in the social sciences literature (e.g. Rousseau et al., 1998). As we pick apart this "trust bundle" and more explicitly model each concept and idea, perhaps we begin to capture the most important elements of trust in other more concrete variables, such as active membership in a community organization or an expression of high concern for the affects pesticides may have on a neighbor's drinking supply. In other words, as we are more careful in how we model cooperation, hazy concepts such as general trust become less important, while more concrete concepts such as whether or not a farmer gets pest control information from agricultural extension agents, become more important. Concrete concepts are also more actionable and give the potential social entrepreneur or policy-maker a direction to explore, such as dissemination of pesticide information, when attempting to organize farmers or encourage farmers to cooperate.

We propose that future research cooperative pest control research should be directed toward more concrete concepts, such as context-specific trust, potential net benefits to providers, unequal distribution of benefits within a cooperative and organizational factors. In addition, we propose that potential social entrepreneurs and policy-makers concentrate on concrete factors such as perceived benefit, environmental concern, pest control information dissemination and social capital acquisition, when considering how to use the information from this study to encourage and create opportunities for farmers to cooperate to control pests.

8. References

Acedo-Carmona, C. and A. Gomila. 2014. Personal Trust Increases Cooperation beyond General Trust. *PloS one*, *9*(8):e105559.

Arrow, K. J. 1974: *The Limits of Organization*. New York: Norton.

Ayer, H. W. 1997. Grass roots collective action: agricultural opportunities. *Journal of Agricultural and Resource Economics*, 1–11.

Baker, B. P. 1988. Pest control in the public interest: Crop protection in California. *UCLA J. Environmental Law & Policy*, *8*:31.

Bhattacharya, R., T. M. Devinney, and M. M. Pillutla. 1998. A formal model of trust based on outcomes. *Academy of Management Review*, *23*(3):459–472.

Bianchi, F., CJH Booij, and T. Tscharntke. 2006. Sustainable pest regulation in agricultural landscapes: a review on landscape composition, biodiversity and natural pest control. *Proceedings of the Royal Society B: Biological Sciences* 273(1595):1715.

Bigley, G. A., and J. L. Pearce. 1998. Straining for shared meaning in organization science: Problems of trust and distrust. *Academy of Management Review*, *23*(3):405–421.

Brehm, J., and W. Rahn. 1997. Individual-level evidence for the causes and consequences of social capital. *American journal of political science*, 999-1023.

Castelfranchi, C. and R. Falcone. 2000, January). Trust is much more than subjective probability: Mental components and sources of trust. In *System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conference on* (pp. 10-pp). IEEE.

Colquitt, J. A., B. A. Scott, and J. A. LePine. 2007. Trust, trustworthiness, and trust propensity: a meta-analytic test of their unique relationships with risk taking and job performance. *Journal of Applied Psychology*, *92*(4):909.

Cong, R. G., H. G. Smith, O. Olsson and M. Brady. 2014a. Managing ecosystem services for agriculture: Will landscape-scale management pay? *Ecological Economics* 99:53-62.

Cong, R. G., K. Hedlund, H. Andersson, and M. Brady. 2014b. Managing soil natural capital: an effective strategy for mitigating future agricultural risks? *Agricultural Systems*, 129:30-39.

Cook, K. S., R. Hardin. and M. Levi. 2005. *Cooperation without trust?*. Russell Sage Foundation. 272 pp.

Costa, A. C., R. A. Roe, and T. Taillieu. 2001. Trust within teams: The relation with performance effectiveness. *European journal of work and organizational psychology*, 10(3):225-244.

Cumming, G., D. Cumming and C. Redman. 2006. Scale mismatches in social-ecological systems: causes, consequences, and solutions. *Ecology and Society 11*(1): 14.

Cumming, G. S., and B. J. Spiesman. 2006. Regional problems need integrated solutions: Pest management and conservation biology in agroecosystems. *Biological Conservation* 131(4):533-543.

Davenport, M. A., J. E. Leahy, D. H. Anderson, and P. J. Jakes. 2007. Building trust in natural resource management within local communities: A case study of the Midewin National Tallgrass Prairie. *Environmental Management*. 39:353–368.

Dent, D. (Ed.) 1995. *Integrated Pest Management*. Springer. 356pp.

Fernandez-Cornejo, J., E. D. Beach, and W. Y. Huang. 1994. The adoption of IPM techniques by vegetable growers in Florida, Michigan and Texas. *Journal of Agricultural and Applied Economics*, *26*:158-158

Flint, M. L. 2012. *IPM in practice: principles and methods of integrated pest management*. Vol. 3418 UCANR Publications. 131 pp.

Frege, C. M. 1996. Union Membership in Post-Socialist East Germany: Who Participates in Collective Action?. *British Journal of Industrial Relations*, *34*(3), 387-413.

Gambetta, D. 2000. Can We Trust Trust?, in Gambetta, Diego (ed.) *Trust: Making and Breaking Cooperative Relations*, electronic edition, Department of Sociology, University of Oxford, chapter 13, pp. 213-237, <http://www.sociology.ox.ac.uk/papers/gambetta213-237.pdf

Gedikoglu, H. and L. M. J. McCann. 2010. What causes farmers to adopt agricultural and conservation technologies and how can we use that knowledge to improve policies, programs and technologies. In: *Human Dimensions of Soil and Water Conservation: A Global Perspective.* Editor: T. L. Napier. Nova Science Publishers Inc.

Goldman, R. L., B. H. Thompson and G.C. Daily. 2007. Institutional incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. *Ecological Economics* 64:333-343.

Hansen, M. H., J. L. Morrow, and J. C. Batista. 2002. The impact of trust on cooperative membership retention, performance, and satisfaction: an exploratory study. *The International Food and Agribusiness Management Review*, *5*(1):41–59.

Hardin, R. 2002. *Trust and trustworthiness*. Russell Sage Foundation.

Hendrickson, M. K. and H. S. James. 2005. The ethics of constrained choice: How the industrialization of agriculture impacts farming and farmer behavior. *Journal of Agricultural and Environmental Ethics* 18(3): 269-291.

James, H. S. and M. E. Sykuta. 2005. Property Right and Organizational Characteristics of Producer-owned Firms and Organizational Trust. *Annals of Public and Cooperative Economics*, 76(4):545–580.

James, H. S. and M. E. Sykuta. 2006. Farmer trust in producer-and investor-owned firms: Evidence from Missouri corn and soybean producers. *Agribusiness*, *22*(1):135–153.

Jones, E. C. 2004. Wealth-Based Trust and the Development of Collective Action. *World Development*, *32*(4):691–711.

Jones, G. R., and J.M. George. 1998. The experience and evolution of trust: Implications for cooperation and teamwork. *Academy of Management Review*, *23*(3):531–546.

Kahan, D. M. 2003. The Logic of Reciprocity: Trust, Collective Action, and Law. *Michigan Law Review*, *102*(1):71–103.

Kramer, R. M. 1999. Trust and distrust in organizations: Emerging perspectives, enduring questions. *Annual review of psychology*, 50(1):569-598.

Leach, W. D. and P.A. Sabatier. 2005. To Trust an Adversary: Integrating Rational and Psychological Models of Collaborative Policymaking. *American Political Science Review*, null(04), 491–503.

Lee, M. K., and E. Turban. 2001. A trust model for consumer internet shopping. *International Journal of electronic commerce*, 6(1):75-91.

Liu, X., R. J. Magjuka, and S. H. Lee. 2008. The effects of cognitive thinking styles, trust, conflict management on online students' learning and virtual team performance. *British Journal of Educational Technology*, *39*(5):829-846.

Lochner, K., I. Kawachi, and B. P. Kennedy. 1999. Social capital: a guide to its measurement. *Health and Place 5*(4):259-270.

Lubell, M., M. Schneider, J. T. Scholz, and M. Mete. 2002. Watershed partnerships and the emergence of collective action institutions. *American Journal of Political Science* 46(1): 148-163.

Lubell, M. 2004. Collaborative watershed management: A view from the grassroots. *Policy Studies Journal*, 32:341–361.

Lubell, M. 2007. Familiarity breeds trust: Collective action in a policy domain. *Journal of Politics*, 69(1): 237–250.

Lundqvist, L. J. 2001. Games Real Farmers Play: Knowledge , memory and the fate of collective action to prevent eutrophication of water catchments. *Local Environment*, 6(4):407–419.

Marshall, G. R. 2004. Farmers cooperating in the commons? A study of collective action in salinity management. *Ecological Economics*, *51*(3):271–286.

McAllister, D. J. 1995. Affect-and cognition-based trust as foundations for interpersonal cooperation in organizations. *Academy of management journal*, 38(1):24-59.

McKnight, D. H., and N. L. Chervany. 2000. What is trust? A conceptual analysis and an interdisciplinary model. *AMCIS 2000 Proceedings*, 382.

Minkler, L. P., and T. J. Miceli. 2004. Lying, integrity, and cooperation. *Review of Social Economy*, *62*(1):27-50.

Morgan, R. M., and S. D. Hunt. 1994. The commitment-trust theory of relationship marketing. *The Journal of Marketing*, 20-38.

MU Plant Sciences. 2012. *MU Pest Monitoring Network: Integrated Pest Management.* Retrieved from http://ipm.missouri.edu/pestmonitoring

Nannestad, P. 2008. What have we learned about generalized trust, if anything? *Annual Review of Political Science*, 11:413-436.

Ole Borgen, S. 2001. Identification as a Trust-Generating Mechanism in Cooperatives. *Annals of Public and Cooperative Economics*, 72(2):209–228.

Österberg, P., and J. Nilsson. 2009. Members' perception of their participation in the governance of cooperatives: the key to trust and commitment in agricultural cooperatives. *Agribusiness*, 25(2):181–197.

Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press.

Ostrom, E. 2001. Reformulating the Commons. In *Protecting the Commons: A Framework for Resource Management in the Americas*, ed. Joanna Burger, Elinor Ostrom, Richard B. Norgaard, David Policansky,and Bernard D. Goldstein. Washington, DC: Island Press, 17–41.

Ostrom, E. 2014. Collective action and the evolution of social norms. *Journal of Natural Resources Policy Research*, 6(4):235-252.

Palmer, S., F. Fozdar, and M. Sully. 2009. The effect of trust on West Australian farmers' responses to infectious livestock diseases. *Sociologia Ruralis* 49:360–374.

Payton, M. A., D. C. Fulton, and D. H. Anderson. 2005. Influence of place attachment and trust on civic action: A study at Sherburne National Wildlife Refuge. *Society & Natural Resources* 18:511–528.

Pelosi, C., M. Goulard and G. Balent. 2010. The spatial scale mismatch between ecological processes and agricultural management: Do difficulties come from underlying theoretical frameworks? *Agriculture, Ecosystems & Environment* 139(4):455-462.

Phan, M. B. 2008. We're all in this together: context, contacts, and social trust in Canada. *Analyses of Social Issues and Public Policy* *8*(1):23-51.

Pontius, J., Dilts, R. and A. Bartlett (eds.). 2002**.** *From farmer field schools to community IPM: ten years of IPM training in Asia.* FAO Regional Office, Bangkok, Thailand.

Pretty, J. and D. Smith. 2004. Social capital in biodiversity conservation and management. *Conservation Biology*, *18*(3):631–638.

Pretty, J. and H. Ward. 2001. Social Capital and the Environment. *World Development*, *29*(2):209–227.

Prokopy, L. S., K. Floress, D. Klotthor-Weinkauf, and A. Baumgart-Getz. 2008. Determinants of Agricultural Best Management Practice Adoption: Evidence from the Literature. *Journal of Soil and Water Conservation* 63(5): 300–311.

Putnam, R. D. 1995. Tuning in, tuning out: The strange disappearance of social capital in America. *PS: Political Science and Politics*, 28(04):664-683

Raedeke, A. H., C. H. Nilon, and J. S. Rikoon. 2001. Factors affecting landowner participation in ecosystem management: a case study in south-central Missouri. *Wildlife Society Bulletin* 29(1):195-206.

Roe, B. E., M. T. Batte, and F. Diekmann. 2014. Competition between local dealerships and internet markets: The role of local relationships, risk tolerance, and trust in used farm machinery markets. *Agribusiness*, *30*(3):225-243.

Rotter, J. B. 1980. Interpersonal trust, trustworthiness, and gullibility. *American Psychologist*, *35*(1):1-7.

Rousseau, D. M., S. B. Sitkin, R. S. Burt, and C. Camerer. 1998. Not so different after all: A cross-discipline view of trust. *Academy of Management Review*, *23*(3):393–404.

Sabatier, P. A., and H. C. Jenkins-Smith. (Eds.). 1993. *Policy change and learning: an advocacy coalition approach*. Boulder, Colo: Westview Press.

Shaw, J. D., M. K. Duffy, and E. M. Stark. 2000. Interdependence and preference for group work: Main and congruence effects on the satisfaction and performance of group members. *Journal of Management*, *26*(2), 259-279.

Smith, J. W., J. E. Leahy, D. H. Anderson, and M. A. Davenport. 2013. Community/agency trust and public involvement in resource planning. *Society & Natural Resources*, 26(4):452-471.

Stallman, H. R. 2011. Ecosystem services in agriculture: determining suitability for provision by collective management. *Ecological Economics*, 71:131–139.

Stallman, H.R. and James, H. S. 2015. In review at *Ecological Economics*.

Stemerding, P., A. Musch, and Y. Diarra. 2002. *c* FAO. Rome. 46 pgs.

Stern, M. J. 2010. Payoffs vs. process: Expanding the paradigm for park/people studies beyond economic rationality. *Journal of Sustainable Forestry*. 29(2–4):174–201.

Stern, M. J. and K. J. Coleman. 2015. The Multidimensionality of Trust: Applications in Collaborative Natural Resource Management. *Society & Natural Resources*, *28*(2):117–132.

Sternberg, R. J. 1997. *Thinking styles.* New York: Cambridge University Press.

Tette, J., J. Kovach, M. Schwartz and D. Bruno. 1987. IPM in New York Apple Orchards-Development, Demonstration, and Adoption. *New York's Food and Life Sciences Bulletin* 119. http://hdl.handle.net/1813/5150

Tscharntke, T., A. Klein, A. Kruess, I. Steffan-Dewenter & C. Thies. 2005. Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. *Ecology Letters* 8:857–874.

Uetake, T. (2014). Agri-environmental Resource Management by Large-scale Collective Action: Determining KEY Success Factors. *The Journal of Agricultural Education and Extension*, (ahead-of-print), 1-16.

van de Fliert, E. (1997, November). From pest control to ecosystem management: how IPM training can help. In *International Conference on Ecological Agriculture, Chandigarh, India, also available at http://www. eseap. cipotato. org/MF-ESEAP/Fl-Library/97-ICEA. pdf*.

Van Dyne, L., D. Vandewalle, T. Kostova, M. E. Latham, and L. L. Cummings. 2000. Collectivism, propensity to trust and self-esteem as predictors of organizational citizenship in a non-work setting. *Journal of Organizational Behavior, 21*(1), 3-23.

Wondolleck, J. M. and S. L. Yaffee. 2000. *Making collaboration work: Lessons from innovation in natural resource management.* Washington, D.C.: Island Press. 277 p.

Zaheer, A., B. McEvily, and V. Perrone. 1998. Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. *Organization science*, *9*(2):141-159.

Zhu, W., A. Newman, Q. Miao, and A. Hooke. 2013. Revisiting the mediating role of trust in transformational leadership effects: Do different types of trust make a difference?. *The Leadership Quarterly*, *24*(1): 94-105

CHAPTER FIVE

Concluding Remarks on
The Cooperative Provision of Ecosystem Services in Agriculture

Agricultural ecosystems provide many ecosystem services (ES) which are essential to human health and well-being, such as flood control services, carbon sequestration, recreation services and water cycling. In turn, some ES affect agricultural productivity, including soil fertility and pollination services (Dale and Polasky, 2007). Managing agricultural lands to provide more ES and higher quality ES may be essential for the long-term sustainability of agricultural ecosystems (Antle and Capalbo, 2001; Swinton et al., 2007). Most agricultural lands, however, are managed for the short-term production of food, fiber, and fuel, often at the expense of other ES (Swinton et al., 2007). Cooperative solutions where stakeholders work together to provide ES may increase the provision of ES in agriculture (Goldman, 2007). However, little is known about which ES are best suited for collective management, whether farmers in North America are willing to cooperate, and what factors might affect their willingness. This dissertation fills this research gap by answering three basic questions about cooperative ES provision: 1) Which agricultural-related ES are suited for collective management, 2) Are farmers willing to cooperate to provide the ES, natural pest control, and if so, what types of cooperation are they will to consider and what determinants affect that willingness, and 3) What role do different types of trust play in farmers' willingness to cooperate to control pests?

1. Summary of Important Results:

In Essay 1, I develop a framework to determine which agricultural-related ES are suited for collective management and which are not. I then use the framework to evaluate the suitability of fourteen agricultural-related ES to collective management. I find that two of the fourteen ES, pollination and pest control, are highly suited to provision through collective management. Two more, water purification and flood control, are suited to collective management, while another five (recreation, biodiversity, habitat provision for mega fauna, esthetic landscapes, and soil retention) are moderately suited. The final four ES (habitat for micro fauna, soil fertility, soil structure, and carbon sequestration) were not suited for collective provision.

In the development of my framework, I identified one resource characteristic—the potential for enhancement through landscape level management—which is essential for determining whether or not an ES may be a candidate for collective provision in agricultural ecosystems. Without this potential, a substantial collective benefit is unlikely to occur, giving farmers little or no incentive to participate in a group activity with high transaction costs (Olson, 1965). In my analysis, four of fourteen ES were not suited for collective management based on this resource characteristic alone. Thus, society must consider resource characteristics, especially the potential for enhancement through landscape level management, when choosing how to approach the ES underprovision problem.

The remaining five characteristics in my framework are concerned with the costs and benefits of cooperating, and they help differentiate between ES that are good candidates for provision through collective management and those that are marginal candidates. Unlike with the first characteristic, an unfavorable classification for any of these characteristics may be overcome depending on the context and regional importance of the ES. For example, in the 1990s water quality became so important in New York City that diverse citizens in the neighboring rural counties were able to overcome problems of heterogeneity, a large number of participants, and a lack of direct benefits in order to supply the city with higher water quality and themselves with the indirect benefit of escaped regulatory pressure (Hoffman, 2008; Salzman et al., 2001).

I continue my investigation into cooperative solutions for the provision of ES in agriculture in Essay 2 where I further explore one of the ES that I classified as highly suited for collective management, natural pest control. Specifically, I asked whether

Missouri crop farmers are willing to cooperate to control pests, what types of cooperation they are willing to consider, what determinants may affect their willingness, and whether those determinants follow the predictions of the collective action literature, the agricultural adoption literature or the ecosystem management literature. I find that most Missouri crop farmers are willing to cooperate to control pests and that simple, small-scale and local cooperative efforts are more popular with farmers than formal, larger-scale and regional efforts. I find that the determinants that affect local cooperative pest control efforts, may be different than the determinants that affect regional efforts. Additionally, the determinants that affect willingness to cooperate to control pests closely follow those predicted by collective action theory, the agricultural adoption literature and the ecosystem management literature.

Farmers who believe they will receive a benefit from cooperation and who have strong social capital are more willing to cooperate than those that do not, as predicted by all three bodies of literature. Farmers who are highly concerned about the affect pesticides may have on the environment are more willing to cooperate than those that are not concerned about the environment, as predicted by the agricultural adoption literature and the ecosystem management literature. Additionally, farmers who rely on agricultural extension agents for pest control information are more likely to participate in cooperative pest control than those that do not rely on agricultural extension agents, as predicted by the agricultural adoption and ecosystem management literature. Finally, in four models, I find that farmers who perceive that their farms and farm operations are similar to their neighbors' farms and farm operations are more willing to cooperate than those that do not perceive this similarity, as predicted by collective action theory.

Only two of seven predictor variables, the one for trust and the one for familiarity, were not significant in any model in Essay 2. Collective action theory states that a person's trust in other members of a group affects the person's willingness to work with that group to achieve a positive benefit (e.g. Ostrom, 1990). It may seem that this aspect of collective action theory does not apply to cooperative pest control, and that trust in one's neighbor does not affect farmers' willingness to cooperate to control pests. However, it is possible we did not measure the most important type of trust in this study.

Scholars recognize that there are different types of trust (e.g. Rousseau et al., 1998), and that these different types of trust may affect cooperation in different ways (Zaheer et al., 2008; Zhu et al., 2013; Stern, 2010). Thus, Essay 3 further explores the role trust may play in a farmers' stated willingness to cooperate to control pests by evaluating how different types of trust affect farmers' willingness to cooperate to control pests and under what conditions trust may matter. I find that most farmers are willing to cooperate to control pests and that most are willing to trust others. Most scholars believe that trust fosters cooperation in social and economic situations (e.g. Hardin, 2002). My analysis, however, presents a more cautious view. In particular, I find little support for our hypothesis that trust is important in farmers' stated willingness to cooperate to control pests.

My analysis weakly supports the idea that different types of trusts have varied effects on farmers' stated WTC to control pests, and that trust affects different types of cooperative pest control in different ways. In addition, I find that some types of trust are only important for farmers’ WTC under certain conditions. For example, farmers whose farms are not similar to neighboring farms are more willing to cooperate if they trust other farmers in their community, than if they do not. However, a farmers' trust in other farmers does not matter if their farms are similar. In addition, a famers' level of general trust seems to only be important to farmers who do not like to work in groups. Farmers who prefer to work alone are more likely to be willing to cooperate if they have high general trust than if they have low general trust.

My analysis strongly suggests that trust as an individual construct is much less important to farmers' WTC cooperate than my control variables, where were the determinants I identified in Essay 2. In fact, some of the effects of trust were likely captured by other variables in the model, especially positive exposure to agricultural extension agents, social capital and the preference for group work. Trust is a nebulous bundle of ideas and concepts that is defined and operationalized in numerous ways in the social sciences literature (e.g. Rousseau et al., 1998). As we pick apart this "trust bundle" and more explicitly model each concept and idea, it is likely that murky concepts such as trust become less important, while concrete concepts such as whether or not a farmer gets pest control information from agricultural extension agents, become more important. Concrete concepts are also more actionable and give the potential social entrepreneur or policy-maker a direction to explore, such as dissemination of pesticide information, when attempting to organize farmers or encourage farmers to cooperate.

Perhaps the most surprising result from Essay 3, however, is finding that my control variable, *Likes to Work in Groups,* may be the most important determinant in farmers' stated willingness to cooperate to control pests. The coefficients for *Likes to Work in Groups* were consistently the largest in magnitude of all the coefficients for the dichotomous variables in the model, plus they were the most highly significant coefficients in all of the models considered in my study. For this dissertation, I have decided to leave this result embedded in the essay about trust. However, the personality trait of whether a person prefers to work in a groups to solve a mutual problem or prefers to work alone has rarely been considered in the collective action literature. For publication, it may serve this result better, if I develop it into a separate essay where I could concentrate on the importance this personality characteristic may have on collective action in general and more specifically, the affect it has on farmers' stated willingness to cooperate to control pests.

2. Importance of Dissertation

Sandler (1992, p. 18) claims that "some forms of collective action come naturally, while other forms need government intervention." Likewise, many scholars propose that society needs to create more policies that provide incentives for people to cooperate in the provision of ES (e.g. Goldman et al., 2007). In fact, some scholars claim that government policies which induce cooperation may be the most cost effective way to provide ES (e.g. Hodge and McNally, 2000). In other words, the most effective approach for addressing the underprovision of ES in agricultural ecosystems may be a combination of the three major approaches—government solutions, market solutions, and cooperative solutions.

This dissertation is important because it provides social entrepreneurs, policy makers, and scholars with information that may allow them to better encourage cooperative solutions for the underprovision of ES in agriculture, independently or through government programs and policies. Specifically, this dissertation determines which agricultural-related ES may best be managed cooperatively, which cooperative pest control activities Mid-western farmers may be willing to consider, and what determinants affect farmers' willingness to cooperate. In addition, this dissertation supplies strong evidence that the adoption of cooperative pest control will follow theory from the agricultural adoption literature, the collective action literature, and the ecosystem management literature, giving scholars, policy makers and social entrepreneurs a wider base of literature to draw from when considering how to move cooperative solutions from speculation to practice. Specifically, I propose that potential social entrepreneurs and policy-makers concentrate on concrete concepts such as perceived benefit, environmental concern, pest control information dissemination and social capital acquisition, when considering how to use the information from this study to encourage and create opportunities for farmers to cooperate to control pests

Most proposed policies which combine two or three of the major approaches to underprovision are designed to induce voluntary cooperation among providers. Three examples are the agglomeration bonus, the cooperation bonus, and the entrepreneur incentive—all of which increase the benefits paid to providers for those who cooperate with other landowners to enhance ES provision at the landscape level (Parkhurst and Shogren, 2007, and Goldman et al. 2007). One proposed policy, however, includes an element of coercion--ES conservation districts--which Olson (1968) predicts will increase the likelihood that collective action succeeds (Parkhurst and Shogren, 2007, Heal et al., 2001, and Goldman et al. 2007). More research is needed to determine what policies and incentives may best induce collective management of ES in agricultural ecosystems.

More research is also needed on the specific costs and benefits of cooperative pest control and the cooperative provision of other agricultural-related ES, and how those costs and benefits affect farmers' willingness to cooperate. For example, one type of trust that I did not consider in Essay 3 was rational trust, a type of trust based on the costs and benefits of trusting. However, it is possible that all trust types could be considered rational. Although scholars do not agree on a common definition of trust, most agree that it must include essential elements, one of which is the expectation of a positive outcome (Hardin, 2002; Rousseau et al., 1998). This expectation implies a rational belief that the benefits of the activity for which trust is required will outweigh the costs, despite uncertainty and risk. Learning more about these costs and benefits may help social entrepreneurs and policy makers to mitigate the costs and enhance the benefits of cooperative ES provision. In addition, many of these costs and benefits may be unequally shared among providers (e.g. Cong et al., 2014), so the effect unequal benefits may have on farmers' willingness to cooperate to provide ES must also be considered.

Finally, more research is needed on the bundling of cooperative ES provision. In Essay 1, I discover that some ES are uniquely suited to bundling, which makes them more suited to cooperative provision. For example, farmers who provide one ES, such as water quality, are in the position to enhance the quantity and quality of other ES at the same time, such as flood control, habitat provision, pest control, and pollination services. More research is needed on how to encourage farmers and other landowners to consider more than one ES in their cooperative provision efforts. In addition, bundling the provision of ES may make voluntary ES provision in agriculture more attractive to farmers and other land owners, by increasing the benefits they receive.

3. References:

Antle, J. M, and S. M Capalbo. 2002. Agriculture as a managed ecosystem: policy implications. *Journal of Agricultural and Resource Economics* 27(1):1-5.

Cong, R. G., H. G. Smith, O. Olsson and M. Brady. 2014. Managing ecosystem services for agriculture: Will landscape-scale management pay? *Ecological Economics* 99:53-62.

Dale, V. H., and S. Polasky. 2007. Measures of the effects of agricultural practices on ecosystem services. *Ecological Economics* 64:286-296.

Goldman, R. L., B. H. Thompson and G.C. Daily. 2007. Institutional incentives for managing the landscape: Inducing cooperation for the production of ecosystem services. *Ecological Economics* 64:333-343.

Hardin, R. 2002. *Trust and trustworthiness*. Russell Sage Foundation.

Heal, G., G. C Daily, P. R Ehrlich, and J. Salzman. 2001. Protecting natural capital through ecosystem service districts. *Stanford Environmental Law Journal* 20:333-364.

Hodge, I., and S. McNally. 2000. Wetland restoration, collective action and the role of water management institutions. *Ecological Economics* 35:107–118.

Hoffman, J. 2008. Watershed shift: Collaboration and employers in the New York City Catskill/Delaware Watershed from 1990-2003. *Ecological Economics* 68:141–161.

Olson, M. 1965. *The logic of collective action: Public goods and the theory of groups*. Harvard University Press.

Parkhurst, Gregory M., and Jason F. Shogren. 2007. Spatial incentives to coordinate contiguous habitat. *Ecological Economics* 64:344-355.

Rousseau, D. M., S. B. Sitkin, R. S. Burt, and C. Camerer. 1998. Not so different after all: A cross-discipline view of trust. *Academy of Management Review, 23*(3):393–404.

Salzman, J., B. H Thompson Jr, and G. C Daily. 2001. "Protecting ecosystem services: Science, economics, and law." *Stanford Environmental Law Journal* 20:309.

Sandler, T. 1992. *Collective Action, Theory and Applications.* Ann Arbor: The University of Michigan Press.

Stern, M. J. 2010. Payoffs vs. process: Expanding the paradigm for park/people studies beyond economic rationality. *Journal of Sustainable Forestry*. 29(2–4):174–201.

Swinton, S. M., F. Lupi, G. P. Robertson and S. K. Hamilton. 2007. Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits. *Ecological Economics* 64:245-252.

Zaheer, A., B. McEvily, and V. Perrone. 1998. Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. *Organization science*, *9*(2):141-159.

Zhu, W., A. Newman, Q. Miao, and A. Hooke. 2013. Revisiting the mediating role of trust in transformational leadership effects: Do different types of trust make a difference?. *The Leadership Quarterly*, *24*(1): 94-105

Appendix A:

COOPERATIVE PEST CONTROL SURVEY

We want to know your opinion about pest control. Please answer all questions as completely as possible. This survey should take about 15 - 20 minutes to complete. Your responses will remain anonymous. Thank you!

YOUR FARM AND FARMING OPERATIONS

1.) Please tell us which statement most accurately describes your current status (select only one):
___ I am an agricultural producer (e.g. farmer, rancher, orchardist, etc.)
If so, are you ___ Fulltime or ___ Part-time
___ I am a landowner only (I do not farm my land)
___ I am retired
___ Other (please explain): ____

2.) How many acres do you farm? __________
Of this amount, how many acres do you: __________own __________rent

3.) How many years have you been farming? __________

4.) What agricultural products do you produce (check all that apply)?
___ Corn ___ Soybeans ___ Wheat ___ Cotton ___ Vegetables
___ Fruit ___ Poultry ___ Hogs ___ Beef cattle ___ Dairy cattle

___ Other Crops or Livestock (please list):________________________

5.) Approximately what were your total farm **sales** in 2011 **excluding** government farm program payments?
_____Under $10,000 _______$10,000 to $50,000 ________$50,000 to $100,000 _______ $100,000 to $250,000 ________$250,000 to $500,000 _______$500,000 – 1 million ____over 1 million

6.) Think about the farming and non-farming sources of your total **gross** income in 2011. What percentage was from **farming sources**?
_____ 0 – 25% _____ 26 – 50% _____ 51 – 75% _____ 76 -100%

7.) In 2011, did you produce any agricultural products that you sold as organic?
___ No ___ Yes, as certified ___ Yes, but not certified **If YES**, what was the product?____________

8.) In the past three years, have you used integrated pest management (IPM) to control for crop pests?
_______ Yes _______ No _______ Don't Know

8.b) If NO, please indicate your level of interest or disinterest in using IPM in the future.
___ Very Interested ___ Somewhat Interested ___ Not Interested or Disinterested
___ Somewhat Disinterested ___ Very Disinterested

9.) Please check which of the following farming practices or activities you have participated in during the past 5 years (check all that apply).

___ Applied synthetic or chemical pesticides to crops
___ Used biological pest control practices on crops
___ Scouted fields for pest damage or pest outbreaks
___ Set aside land for pollinating or predatory insect habitat
___ Used crop rotations to control for insects, weeds or other crop pests

10.) Have you ever participated in an ecosystem management program, such as a conservation cooperative to provide wildlife habitat or a watershed management program to improve water quality?

_______Yes _______ No _______ Don't Know

YOUR ATTITUDES AND PERCEPTIONS ABOUT PEST CONTROL

In this survey **pest** refers to any unwanted organism that causes crop damage, such as insects, weeds or fungus. **Pesticide** refers to any product used to reduce pests, such as insecticides, herbicides and fungicides.

11.) Do you believe that pest control problems **on your farm** have become worse, stayed the same, or improved since you started farming?
___ Become worse ___ Stayed the same ___ Improved

12.) Do you believe that pest control problems in agriculture **in general** have become worse, stayed the same, or improved since you started farming?
___ Become worse ___ Stayed the same ___ Improved

13.) Where do you get information about pest control management practices (check all that apply)?

___ Family
___ Friends or Neighbors
___ Agricultural Extension Agent
___ Pesticide Sales Representative
___ Magazine or Newsletter
___ Internet
___ Other (please list)____________________________

14.) Circle the number to indicate how much you agree or disagree with each statement.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree	Don't know
a. Natural populations of pest predator insects are important for agriculture.	1	2	3	4	5	0
b. Increasing the number of pest predator insects in my county will help my farm.	1	2	3	4	5	0
c. I am willing to lose some of my crop to pest damage as long as I don't experience major pest outbreaks or major damage.	1	2	3	4	5	0
d. My neighbors' pest management practices affect my ability to manage pests on my farm.	1	2	3	4	5	0
e. Pest insects travel from farm to farm and county to county.	1	2	3	4	5	0
f. Weed seeds "travel" from farm to farm and county to county.	1	2	3	4	5	0
g. If my neighbor sets aside land to increase predatory insects or pollinators on his farm, it only helps my neighbor's farm.	1	2	3	4	5	0
h. When I apply insecticides to my fields, it only affects my farm.	1	2	3	4	5	0
i. If my neighbors and I worked together, we could manage pests more effectively.	1	2	3	4	5	0
j. If a corn farmer anywhere in my county has a pest outbreak, I need to prepare for a pest outbreak in my corn fields, too.	1	2	3	4	5	0
k. The pest management practices of all landowners in my county affect my ability to manage pests on my farm.	1	2	3	4	5	0
l. It would be easier to control pests using crop rotations if most farmers in my county would coordinate their crop rotations.	1	2	3	4	5	0
m. It would be easier to prevent pesticide resistance in pests if most farmers in my county would coordinate the timing and amount of pesticides they use.	1	2	3	4	5	0

15.) Are you interested in decreasing pesticide use on your farm?

___ Yes ____ No ___ Don't Know ___ I don't use pesticides

16.) Here is a list of concerns farmers may have about pesticides. For each one, please circle the number that indicates your level of concern.

	Highly Concerned	Somewhat Concerned	Not Concerned
The cost of pesticides	2	1	0
The affect applying pesticides may have on farmers' health	2	1	0
The affect pesticides may have on pest predator insects	2	1	0
The affect pesticides may have on bees and other pollinators	2	1	0
The affect pesticides may have on wildlife	2	1	0
Possible future pesticide regulations	2	1	0
The affect pesticides may have on rural drinking water supplies	2	1	0
The affect pesticides may have on streams, lakes or rivers	2	1	0
Pest resistance to pesticides	2	1	0

17.) Here is a list of ways farmers may be able to **voluntarily** cooperate with each other to achieve Effective pest control, while decreasing the use of pesticides. For each activity, please circle the number to show how willing or unwilling you would be to participate in the activity.

	Very willing	Somewhat willing	Neither willing nor unwilling	Somewhat unwilling	Very unwilling	Don't know
a. Sign up to receive pest outbreak alerts for my county.	1	2	3	4	5	0
b. Share my pest scouting reports with a regional pest coordinator.	1	2	3	4	5	0
c. Learn more about ways farmers can work together to control pests.	1	2	3	4	5	0
d. Work with my closest neighbors to manage pests on our land.	1	2	3	4	5	0
e. Cooperate with my neighbors in scouting for pest outbreaks, so each of us could spend less time scouting.	1	2	3	4	5	0
f. Coordinate the timing and amount of pesticides I use with my neighbors and/or other local farmers.	1	2	3	4	5	0
g. Coordinate the release of biological pest controls with my neighbors and/or other local farmers.	1	2	3	4	5	0
h. Join a **community-wide** pest management cooperative.	1	2	3	4	5	0
i. . Join a **county-wide** pest management cooperative.	1	2	3	4	5	0
j. Participate in a regional effort to coordinate crop rotations.	1	2	3	4	5	0
k. Participate in a regional effort to coordinate crop diversity and the number of acres planted to each crop type.	1	2	3	4	5	0
l. Participate in a **community-wide** effort to coordinate the amount and placement of set aside land for pest predator and pollinating insects.	1	2	3	4	5	0
m. Participate in a **county-wide** effort to coordinate the amount and placement of set aside land for pest predator and pollinating insects.	1	2	3	4	5	0

ABOUT YOU AND YOUR HOUSEHOLD

18.) Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?

___ Most people can be trusted ___ Need to be very careful ___ Don't know

19.) Overall, how would you rate the honesty and integrity of farmers (please check one)?

___ Very High ___ High ___ Average ___Low ___ Very Low ___ No opinion

20.) Given the choice, would you rather work with others in a group to solve a mutual problem or would you rather work alone?

___ Work with others ___ Work alone ___ Don't know

21.) Think of your nearest 4-5 neighbors. How different or similar to your farm are most of your neighbors' farms or properties? Would you say they are:

___ Very Similar ___ Somewhat Similar ___ Not Similar or Different
___ Somewhat Different ___ Very Different

22.) Here is a list of people you may interact with. For each one, please circle the number that corresponds with how trustworthy you believe they are.

	Usually Trustworthy	Sometimes Trustworthy	Rarely Trustworthy
Your Neighbors	2	1	0
Farmers in your Community	2	1	0
Farmers in Missouri	2	1	0
Other Agricultural Professionals	2	1	0
Non-Farmers in your Community	2	1	0
Government Officials	2	1	0
Water Conservation Agents	2	1	0
Wildlife Conservation Agents	2	1	0

23.) Here is a list of voluntary organizations. For each one, please indicate whether you are an active member, an inactive member or not a member of that type of organization.

	Active member	Inactive Member	Not a Member
Agricultural cooperative	2	1	0
Sustainable agricultural organization	2	1	0
Other agricultural organization	2	1	0
Environmental organization	2	1	0
Church or religious organization	2	1	0
Humanitarian or charitable organization	2	1	0
Sports or recreational organization	2	1	0
Other (specify)____________________	2	1	

24.) What is your sex?
___ Male ___ Female

25.) What is your age? ________

26.) What is the highest level of education you completed?
___ Some high school ___ High school or GED equivalent ___ Vocational or technical school
___ College degree (BA, BS) ___ Graduate or professional degree ___Other: _____________

27.) Please provide any additional comments you have about cooperative pest control: _______________

____

____

____

THANK YOU! Please return your completed survey in the enclosed business reply envelope.

VITA

Heidi Stallman was born in Columbia, Missouri, where she grew up on the edge of town and had many adventures with her neighbors' cows, numerous abandoned root cellars and the oak hickory forest that she grew to love. She attended Hickman High School where she was a varsity athlete in basketball, cross country and swimming; the vice president of the biology club; and an active member of the National Honor Society and math team. Next, Heidi attended the University of Missouri where she earned a bachelor of science in biology, after dabbling around for a while in the chemistry, math and physics departments. She graduated at the top of her class and won many honors, including the Phi Beta Kappa Distinguished Scholar Award.

Heidi continued her studies at Iowa State University of Science and Technology, where she developed a love of martial arts and competed for Iowa State on the taekwondo team in three NCAA national championships. She also discovered a love for sustainable agriculture and the grassland birds that depend on farmers' stewardship of the land. She earned her master of science in animal ecology, and spent the next few years teaching at Iowa State University and studying birds, most notably the Northern Spotted Owl on the Olympic Peninsula in Washington.

Heidi has held many interesting jobs, including as an actress, wildlife biologist, camping instructor, free-lance writer, children's tutor, animal rescue worker, plant specimen collector, and painter. She always longed to go back to school, and when she couldn't put off that longing any more, the knocked on Dr. Harvey James' door and convinced him she was interested in pursuing a Ph.D. in economics, although she had never taken an economics course before. This dissertation is the culmination of that journey, where Heidi not only learned to think like an economist, but to also to combine economics with her first two academic loves, ecology and sustainable agriculture.