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thesis entitled

TRADE-OFFS, INCENTIVES AND THE SUPPLY FOR ECOSYSTEM SERVICES FROM CROPLAND

presented by

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has been accepted towards fulfillment
of the requirements for the

Master of Science degree in Agricultural, Food and Resource Economics

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June 12, 2009

Date

TRADE-OFFS, INCENTIVES AND THE SUPPLY OF ECOSYSTEM SERVICES FROM CROPLAND

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Agricultural, Food and Resource Economics

2009

ABSTRACT

TRADE-OFFS, INCENTIVES AND THE SUPPLY OF ECOSYSTEM SERVICES FROM CROPLAND

By

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Agriculture is a managed ecosystem. The decisions of its managers, the farmers, drive the mix of ecosystem services (ES) that it produces. The thesis is divided into two essays. Essay 1 develops tradeoff analysis between profitability and selected environmental indicators for different types of cropping systems using data from agronomic field trials. The tradeoff frontiers developed in the study are profit vis-à-vis global warming potential (GWP) and nitrate leaching. Both reveal that the conventional corn-soybean-wheat rotation treatment is dominated. The organic treatment is dominated unless certified organic prices are used. The no-till cropping system shows potential as an efficient choice for the farmer, as does alfalfa for its GWP. The tradeoffs between no-till and alfalfa for GWP and no-till with certified organic imply that there are opportunity costs to changing cropping systems in order to provide more nonmarketed ES.

Essay 2 uses survey data to examine farmers' willingness to enroll in a program that compensates them for adopting environmental stewardship. Results show that Michigan farmers' acreage enrollment decisions depend consistently on farm size and the perception of environmental improvements from the practices. For farms over 500 acres, the payment offered was also a significant inducement to acreage enrollment in all systems examined. The second essay advances the literature on adoption of agro-environmental practices by developing a supply function for crop acreage managed for environmental stewardship. Like prior studies of environmental technology adoption in agriculture, we find that environmental attitudes and affiliations, age, education and current farming practices are influential. But we also find that the low cost suppliers of environmental services are the largest farms. Agricultural policies based on payment for environmental services that aim for cost-effective environmental impact will likely achieve most of their impact from larger farms.

To God be the glory.

ACKNOWLEDGEMENTS

This thesis is the end of my long journey in obtaining my Masters Degree in Agricultural Economics. There are a lot of people who made this journey easier with words of encouragement and more intellectually satisfying by offering help to expand my theories and ideas.

I first want to thank my assistantship supervisor and thesis committee chair, Dr. Scott M. Swinton. He gave me the confidence and support from the very first day I started my Masters Program. He provided me direction and guidance all throughout the process. He challenged me to set my benchmark even higher and gave me the confidence to pursue my dreams of moving on to pursue my PhD. I learned to believe in my future, my work and myself.

I would also like to thank the members of my committee, Dr. Frank Lupi and Dr. Phil Robertson for their research guidance and for the valuable contributions they made to improve my work and support they have given me along the way.

I am also grateful to the support of Kellogg Biological Station's Long-Term Ecological Research and the members of the National Science Foundation's Human and Social Dynamics program. I would especially like to thank Lenisa Vangel, Robert Shupp, Sara Parr, and Sven Bohm for providing me with ideas and help with data. I greatly appreciate their time and efforts. Also for the National Agricultural Statistics Service staff especially Vince Matthews for help with the survey design and sampling. Also, Natalie Rector for her valuable comments on the survey design.

I would like to express my appreciation to the faculty and staff of the Department of Agricultural, Food and Resource Economics for all their help and support throughout my time here.

Many thanks to my friends and fellow graduate students who helped me with survey work. In particular, Lara de Villa, Feng Song, Huilan Chen, Xuan Wei, Alexandra Peralta, Yong Jiang, Shan Ma, Minh Chen, Jane Zhang and Ping Yuan for all the help with the signing, labeling and mailing of questionnaires. Michelle Corzine, Joleen Hadrich, Nicole Olynk, Marcus Coleman, Jake Ricker-Gilbert and Lee Schulz for the help with the survey design. For the undergraduates who worked with me, thank you for keeping up with me with the deadlines.

I would like to thank my good friends in the MSU Filipino Club, most especially Carmille Bales and Joy Gordoncillo who have brought me so much happiness and support, especially during the stressful survey work and writing stage. Also to my second family here in the US, to the Glatz family who have always welcomed me in their home and treated me like a family for the past years I have been here in the US.

And last but not the least, for all my loved ones. My family, for the love and support that overcome the distance. My parents, Nick and Dollie, and my sisters Tricia, Therese and Trina, it may have cost us a lot of phone cards but all the encouragement and inspiration you give me is priceless; and for Michael James Foreman for being there for me all throughout, supporting me and believing in me.

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LIST OF ACRONYMS

KBS	Kellogg Biological Station
LTER	Long Term Ecological Research
ES	Ecosystem Services
NMES	Non Marketed Ecosystem Services
MRT	Marginal Rate of Transformation
MRS	Marginal Rate of Substitution
CSW	Corn-Soybean-Wheat Rotation
CS	Corn-Soybean Rotation
IPM	Ideal Point Method
PVIFA	Present Value Interest Factor for Annuity
WTA	Willingness to Accept
WTP	Willingness to Pay
CRP	Conservation Reserve Program
CSP	Conservation Security Program
EQIP	Environmental Quality Incentives Program
MEAEP	Michigan's Agriculture Environmental Assurance Program
NASS	National Agricultural Statistics Service
ERS	Economic Research Service
USDA	United States Department of Agriculture
PES	Payment for Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change

Introduction

Agriculture is the world's largest terrestrial ecosystem (Millennium Ecosystem Assessment, 2005). Managed to provide food, fuel and fiber to meet humans' market and subsistence demands, it simultaneously affects and depends on the biophysical and economic settings in which it operates. In so doing, it generates non-marketed ecosystem services (ES), like carbon sequestration into soil or trees, and disservices, like lake eutrophication from phosphorus runoff. These non-marketed ES and disservices come as joint products or byproducts with the intentional food, fiber and fuel products. Braden and Lovejoy (1990) stressed that these residuals and by-products are difficult to quantify and have rarely been priced.

Unlike natural ecosystems, agriculture is a managed ecosystem. The decisions of its managers drive the mix of ES that it produces. Farmers play an important role as ecosystem managers in that they balance their decisions regarding land and other agricultural inputs for production and modify their practices to adjust the positive and negative impacts to the environment (Wossink and Swinton, 2007). By their choices of production inputs and management practices, farmers shape their impacts on the environment.

This thesis is divided into two essays. Essay 1 develops tradeoff analysis between profitability and selected environmental indicators for the different cropping systems from experimental treatment plots located at the Kellogg Biological Station. The objectives of this study are: (1)) to compare the profitability of the cropping systems by constructing enterprise budgets for all the cropping systems, (2) to construct trade-off frontiers between profitability and selected environmental indicators for all the cropping systems and (3) to identify preferred cropping systems from the trade-off frontiers.

Essay 2 examines farmers' willingness to accept compensation to adapt to environmental stewardship practices in Michigan based on the analysis of survey data. Moreover, it advances the literature on adoption of agro-environmental practices by developing a supply function for crop acreage managed for environmental stewardship. The objectives of this paper are: (1) to identify farmer's willingness to accept (WTA) payments for environmental services to adopt to environmental stewardship practices; (2) to investigate the determinants of their willingness to adopt those practices, and the relative importance of these factors; and (3) to estimate empirically the supply curves for acreage enrollment in hypothetical environmental stewardship programs which implicitly expresses how much ecosystem services are farmers willing to produce.

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Essay 1: Profitability and Environmental Stewardship for Row Crop Production: Are There Trade-offs?

1.1 Introduction

Farmers play an important role acting as ecosystem managers that help maintain the natural supporting ecosystem services that make agriculture productive (Swinton, et al., 2006). Moreover, they make choices that can change the type, magnitude and relative mix of services provided by the ecosystems (Rodriguez et al, 2006). By their choice of inputs and management practices, they face important trade-offs such as those between agricultural production and ecosystem services such as biodiversity, water and soil quality.

Careful selection of crop systems involves examining trade-offs between profitability and environmental impact. Gebremedhin and Schwab (1998) provided an extensive literature review on the effects of crop rotations on profitability and the environment. For example, they pointed out that less dependence on external inputs, i.e. less dependence on fertilizer and chemicals, can reduce the costs for the farmers and at the same time using less chemicals is beneficial for environment. Cover crops incur planting costs for the farm but can also improve soil structure, increase soil organic matter, water percolation, beneficial insect population, suppress weeds, reduce soil erosion and fix residual N after the grain is harvested (Gebremedhin and Schwab, 1998; Jones and Ritchie, 1996). Dhuyvetter et al (1996), points out how conservation tillage reduces operation costs as it reduces expenses for labor, fuel, oil, and machinery use costs and at the same time increases water infiltration and water loss from evaporation.

Invariably, the environmental objectives conflict with one another and farmers' choices involve significant tradeoffs.

But what lies behind the farmers' decisions are the incentives they have for doing a particular practice. Empirical studies in the soil conservation literature have shown that the most important motive for adoption is the "selfish", financial-economic concern, or profits including financial attributes in some sense (Chouinard et al, 2008). Cary and Wikinson (1997) and Honlonkou (2004) found that adoption of conservation practices depends on financial economic indicators such as profitability. Graafland (2002) modeled the trade off between profit and stewardship centering upon the profit maximization principle. In a farmer focus group[1] conducted in south-central and central Michigan, several farmers expressed their commitment to environmental stewardship, but felt that profitability and business viability had to come first. One of the farmers said, "I always try to choose practices that have environmental benefits but if it's going to cause me to lose money then I can't take that choice."

On the other hand, a category of literature focuses on social and attitudinal issues in agricultural production, including stewardship motives. Wunderlich (1991) examined the evolution of the concept of stewardship among agricultural producers and stressed that farmers view themselves as stewards and that their farming is a way of life rather than a business to maximize profit. Ryan, Erickson and De Young (2003) examined the motives for protecting biodiversity and water quality in the Midwest. They discovered that an important factor in motivating conservation is attachment to the land, and that

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[1] S.M. Swinton, N. Rector, G.P. Robertson, C.B. Jolejole and F. Lupi. July, 2007. "Ecosystem Services from Farmland: What do farmers think?". Unpublished manuscript.

producers are more likely to engage in a practice that makes their farm appear well managed.

Clearly, the literature shows that there are economic and non-economic conservation incentives. An integrated analysis of economic and environmental indicators of alternative cropping systems can be done using a multi-objective approach grounded in multi-attribute utility theory. Antle et al. (2004) discussed trade off frontier analysis as a modeling system for agricultural and environmental policy analysis. Trade off analysis quantifies the relationship between key economic and environmental indicators at the level of a farm field. For policy analysis, results may be aggregated on a bigger scale.

New crop production technologies have been studied in light of this growing concern for environmental stewardship practices. In particular, Kellogg Biological Station's Long-term Ecological Research (KBS-LTER) project evaluated the environmental benefits from low input crop rotations. The LTER program is a fundamental ecological research network funded by the National Science Foundation. It started in 1980 and now supports more than two dozen field sites in North America, Antarctica and Polynesia. The KBS-LTER founded in 1988 is the site focused on agricultural ecology. It has developed a cropping system that offers comparable yields with less pesticides and fertilizers applied than conventional systems in the northern Cornbelt. Despite the environmental benefits, few farmers have adopted this crop system.

This paper looks at the profitability of the different cropping systems including the low-input crop rotation that KBS developed. Moreover, the paper develops trade off frontiers between profitability and environmental performance using enterprise budgets from Michigan research trials and selected environmental indicators from the KBS. It contributes to the growing body of knowledge about the economic and environmental impact of alternative cropping systems while trade off analysis allows stakeholders to make informed decisions concerning the dual goals of agricultural production and safeguarding the environment.

1.2 Objectives of the Study

The objectives of this study are: (1) to compare the profitability of the cropping systems by constructing enterprise budgets for all the cropping systems, (2) to construct trade-off frontiers between profitability and selected environmental indicators for all the cropping systems and (3) to identify preferred cropping systems from the trade-off frontiers.

1.3 Conceptual Framework: Environment-Profit Trade Offs

The concept of trade off is fundamental to economics and derives from the idea that resources are scarce. Consequently, to obtain more of one scarce good, an individual or society collectively must give up some amount of another good. Trade off analysis applies these principles to derive information about sustainability of agricultural production systems, by quantifying the inter-relationships among environmental indicators implied by the underlying processes and the economic behavior of profit maximization.

The integrated economic and environmental systems have multiple objectives. Thus the idea of a multi-attribute utility function is fitting in assessing these trade offs where a general efficiency rule is used that applies to all decision makers who generally care about the different attributes (King and Robison, 1984).

Following the framework by Chouinard et al (2006), we build on the model of a farmer behavior by integrating environmental attributes from a multi-attribute utility function to determine dominance and production possibilities function (PPF) to determine technical efficiency. It is worth noting that in reality, farmers do not think in terms of production functions rather they think of production technologies and farm practices. Farmers identify a specific combination of inputs and outputs, i.e. practices, as a farm technology.

We start with a multi-attribute utility function. We assume that the farmers would want to maximize a utility function that is increasing in profits π and environmental quality E.

$$Max U = U(\pi, E)\text{;} \quad \frac{\partial U}{\partial \pi} > 0; \frac{\partial U}{\partial E} > 0 \tag{1}$$

Where,

$$E = e(x_E, x_P)\text{;} \quad \frac{\partial E}{\partial x_E} > 0; \frac{\partial E}{\partial x_P} < 0 \tag{2}$$

$$\pi = p_Q Q - p_x x - c_0\text{;} \quad \frac{\partial \pi}{\partial Q} > 0; \frac{\partial Q}{\partial x_P} > 0; \frac{\partial Q}{\partial x_E} > 0 \tag{3}$$

Environmental quality, E, is an increasing function of environmental enhancing inputs, x_E, and decreasing with polluting inputs, x_P. Also profit, π, is a function of output Q, input x, fixed costs c_0, output prices p_Q and input prices p_x.

Figure 1.1 shows a generically shaped PPF. The PPF shows how a fixed resource such as land can be allocated most efficiently between two different outputs. Although traditionally outputs are marketed, they can also include non-marketed services like environmental quality, E. Anything lying inside the frontier is considered a technically inefficient choice. PPF therefore determines technical efficiency.

The slope of the PPF is the marginal rate of substitution between the two outputs. So that the slope, $\frac{\partial \pi}{\partial E}$, shows the marginal rate of technical substitution or the change in profit, π, per unit change in environmental quality, E. This is the implied cost of to the farmer of increasing environmental services provision to improve environmental quality.

A particular farmer, i, maximizes utility where indifference curve, U_i^0 is tangent to the PPF (in particular point A) and produces corresponding profit and environmental quality. For farmer i any point above the indifference curve U_i^0 would be preferred.

Even among individuals whose utility fits the assumptions in Equation (1), the shape of indifference curves for different individuals may differ, meaning that they have different relative preferences between profit, π, and environmental quality, E. This makes this type of analysis appealing because it covers wider type of individuals including policy makers so long as their utility fits this common assumption (King and Robison, 1984).

The shaded area represents points that would be preferred over point A by any farmer whose utility function meets the general assumptions in Equation (1), because it allows one to increase profit and/or decrease environmental damage at the same time. The area could be called the *area of profitability-environmental quality dominance* relative to point A.

This study makes use of two environmental indicators data on global warming potential (GWP) and nitrate leaching which both exhibit negative environmental effect. From this point forward to the end of the section, we will denote to this as environmental damage (ED). Figure 1.2 presents a diagram with measures of environmental damage and profit on the axes.

King and Robison, (1984) noted that an *efficiency criterion* divides the decision alternatives into two mutually exclusive sets: efficient set and inefficient set. The efficient set contains the choice of every individual whose preferences conform to the assumptions associated with the criterion. No element in the inefficient set is preferred by decision makers with the preferences assumed. Thus, inefficient alternative choices are no longer considered in the decision.

More formally, *profit-environmental quality efficiency criterion* is stated in terms of these two conditions, 1 and 2: Outcome distribution1 ith profit π_1 and environmental damage ED_1, dominates outcome distribution 2 with profit π_2 and environmental damage ED_2, if $\pi_1 \geq \pi_2$ and $ED_1 \leq ED_2$ and if one of these two inequalities is strict. *Efficiency criteria* are useful in cases where preferences are not known directly but we do observe technology characteristics (King and Robison, 1984).

In Figure 1.2, point A' is where farmer i maximizes utility. The shaded region represents points that are profit-environmental quality dominant over initial point A' because it allows one to increase profit and/or decrease environmental damage at the same time. Points B and D on the other hand represents tradeoffs relative to point A. Point B is a dominated choice relative to point A because even though it allows the individual to increase profit, environmental damage increases at the same time. The same goes for point D because even though environmental damage is decreased, profit is also decreased. Point C is simply an inefficient choice because it gives lower utility to anyone whose preferences fit equation 1.

The procedure for building trade off frontiers is analogous to risk efficiency with two variables, such as mean-variance efficiency (King and Robison, 1984). The basic idea is to increase the good and decrease the bad (i.e. increase the mean and decrease the variance). Likewise, the farmer tries to increase profit and decrease environmental damage. Efficiency determination involves mapping alternative practices or policies and evaluating their efficiency in the sense of giving the best profitability for a given level of environmental performance, or the best environmental outcome at a given profitability level. Efficient choices will lie on a frontier, where there is a trade-off between improving profitability and environmental performance. The slope of the trade off frontier represents the opportunity cost of environmental choices in terms of reduced farm income (Antle, Capalbo and Crissman, 1998). The steeper the slope, the greater is the opportunity cost for improving the environmental stewardship measured by the foregone profit. Thus, the slope, $\frac{\partial \pi}{\partial ED}$, represents the implicit cost of foregone income from changing the systems to decrease environmental damage.

Moreover, the influence of the exogenous factors can be seen on the shape of the frontier curves and can also be considered as drivers of the production system that could result in a shift of the frontier. This can be referred to as change in system's exogenous drivers as policy, technology or resource change scenarios (Weersink et al, 2002). There are several studies that constructed trade off frontiers. Kelly, Lu and Teasdale (1996) did a simulated analysis of long-term impacts of different cropping systems including trade off analysis of net return and different components of environmental quality. Van der Veeren and Lorenz (2002), looked at the cost effectiveness, spatial equity and sustainability and constructed trade off curves to show relationships among the three.

1.4 Background of the Study: Site and Experimental Treatments

In this study, the trade offs between profitability and some environmental indicators for several cropping systems were constructed and analyzed. The KBS-LTER main experimental site was the source of data for this study. It is a 60 hectare site divided into six different treatments, each one replicated into six one-hectare plots. Four of these seven systems are annual crop rotations and two are perennial crops, namely, alfalfa and poplar.

The annual crops are corn-soybean-wheat rotations (CSW) with four treatments. The conventional cropping system uses university extension recommended chemical inputs and chisel plowing. The no-till system uses conventional chemical inputs and uses no-tillage management. The low-input system uses 2/3 of the chemical inputs as the conventional, banded herbicide and tillage to control weeds, and a winter cover crop in 2 of 3 years. In the organic system, no chemical inputs or manure are used. Mechanical cultivation is used for weed control, and cover crops are used.

Perennial systems include alfalfa and poplar. The poplar treatment is a fast growing *Populus* clone that is fertilized only once when established. It is harvested every 9-10 years and allowed to coppice or regrow from stems. On the other hand, the alfalfa stands are fertilized with phosphorus, potassium, boron and lime according to soil tests and university recommended rates. The alfalfa is harvested 3-4 times per year and replanted every five to six years. Table 1.1 summarizes the differences among the treatments.

The experimental plots for the study are located at W.K. Kellogg Biological Station (KBS) in Hickory Corners, Michigan. The site is located at the northern end of the U.S. Cornbelt, 50 km east of Lake Michigan (42° 24'N, 85° 24'W) on soils developed from glacial outwash deposited 12000 years ago. Annual rainfall averages 890 mm y^{-1} with about half falling as snow and potential evapotranspiration (PET) exceeds precipitation for about 4 months of the year. Mean annual temperature is 9.7 °C. (More information is at http://lter.kbs.msu.edu).

1.5 Types and Sources of Data

The data include agronomic farm data (site specific production and input data), external price data and environmental data (site-specific experimental data for calibration of biophysical models). Agronomic farm data and prices were used in constructing the enterprise budgets to measure profitability. Environmental data were used together with the computed profits to construct trade off analysis.

1.5.1 Agronomic Data

Agronomic data include yields, fertilizer and herbicide application rates, seeding rates, and tillage activities from the KBS-LTER agronomic log. For the cropping systems,15 years of data from 1993 to 2007, equivalent to five complete crop rotations of corn, soybean and wheat was used.[2] While for the perennial systems, the poplar data covered a complete ten-year cycle from 1989 to 1998 and the alfalfa data covered a three complete five-year cycles from 1989 to 2003.

1.5.2 Price and Cost Data

Cost data for this study were collected from a variety of secondary sources in an effort to represent actual prices observed in Michigan. The input and output price sources are presented in tables 1.2 and 1.3, respectively. The price data includes the 1978-2008 National Agricultural Statistics Service (NASS) agricultural prices[3], average organic prices for 2008 from the Economic Research Service of the United States Department of Agriculture (ERS-USDA) website[4], price of fertilizer and herbicides from an agricultural input vendor in Michigan as of April 2008[5], average organic certification

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[2] http://lter.kbs.msu.edu/datasets
[3] http://www.nass.usda.gov/QuickStats/index2.jsp
[4] http://www.ers.usda.gov/Data/OrganicPrices/
[5] Jorgensen Farms Elevator, Pers. Comm., April 24, 2008, Fax request for Input Prices

costs from Institute of Food and Agricultural Sciences of University of Florida, and the cost of tillage operations from the custom machine work rates in the Saginaw Valley and on Iowa State University custom rate survey.

1.5.3 Environmental Data

Crop management practices directly affect the mix of ecosystem services generated. Some environmental indicators, namely global warming potential and nitrate leaching data collected at the Kellogg Biological Station, were used in the trade off analysis.

1.5.3.1 Global Warming Potential

The data used in the study was taken from the Robertson et al (2000) paper measuring the global warming potential of different treatments. Robertson et al (2000) reported that, globally, agriculture is responsible for 20% of the terrestrial greenhouse gas emissions. In particular, the major greenhouse gases coming from agriculture are methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2).

A complete understanding of agriculture's impact on global warming was performed by field-level analysis of all greenhouse gas emission rate fluctuations to derive the net global warming potential (GWP) for the different cropping systems (Robertson et al, 2000). Robertson et al (2000) performed greenhouse gas accounting in which the different gases that come from agriculture were given weighted values according to their "potency as a greenhouse gas". This potency of a gas is referred to by the Intergovernmental Panel on Climate Change (IPCC) as GWP.

1.5.3.2 Nitrate Leaching and Runoff

The data used came from Syswerda (2009) which looked at long-term nitrate loss for different treatments. They sampled soil at different depths, and nitrogen content was measured and recorded to measure leaching. Agricultural nitrogen comes from a wide variety of sources but primarily from inorganic fertilizer, animal waste, and nitrogen fixing plants. The KBS-LTER site includes no animal wastes.

Most crops only take up 50% of nitrogen applied (Syswerda, 2009; Robertson, 1997). The other 50% is subject to loss to the environment including leaching into groundwater (Syswerda, 2009; Fenn et al., 1998; Sanchez et al, 2004). This can impact human health when ingested. Leached nitrates can reach surface water leading to eutrophication and algal blooms, which harm or kill fish and other wildlife (Garrett and Buck, 1997). Ribaudo (2003) estimated the cost of mitigating U.S. water quality impairment due to nitrate in the tens of billions of dollars.

1.6 Methods

The first part of this section presents analysis of enterprise budgets to look at profitability and the second part explains the trade off frontier analysis using environmental data from the KBS-LTER experiments.

1.6.1 Profitability Using Enterprise Budgets

At the farm level, optimizing farmers choose the best cropping system among the technically feasible alternatives. As mentioned earlier, the conservation literature has shown that the most important motive for adoption is the financial-economic concern, or profits.

Profitability is a function of yield, output prices and operation costs which include seed costs, fertilizer, herbicides, insecticides and custom operations costs. Different cropping systems can have different operation costs and yields, thus it is important to use a common index for their comparison – a measure of net financial return to the farm.

This study compares the profitability of different production systems by calculating an annualized net return (annual payment stream with cumulative value equal to the net present value) for each system. The annual systems included the 4 cropping systems and the annualized present value was calculated assuming a balanced rotation where a third of available land is planted to each crop in each year. For the perennial systems, alfalfa and poplar, the analysis assumes three five-year and one ten-year complete cycles respectively. An annualized value was computed by dividing the present values by a present value interest factor for an annuity (Weston and Copeland, 1986, Appendix A.4). The discount rate chosen for this study was 5%, to reflect a real, risk free rate of return.

Enterprise budgeting is one of the most basic production economic tools available (Roberts and Swinton, 1996). It is relatively simple compared to other methods but can still provide a detailed, in-depth analysis. Enterprise budgets represent the estimates of receipts (income or gross returns), costs (fixed and variable costs), and profits associated with the production of agricultural products for an enterprise. They can be used to evaluate how one crop or activity can contribute to the profitability of a certain cropping system and to compare the contributions to profitability of the same crop or practice under different rotations (Gebremehedhin and Schwab, 1998; Christenson et al., 1995; Jones and Ritchie, 1996). Enterprise budgets can be used to rank the profitability of the different systems.

In order to conduct a profitability analysis of different cropping systems, a clear description of each system and its associated practices becomes essential (Table 1.1). If the differences are limited to only part of the farm operation, gross margin analysis of revenues minus costs that vary among treatments suffices for comparison across treatments (CIMMYT, 1988). In this case, the differences among the cropping systems are on the use of cover crops, amount of chemical use and tillage.

This study constructed enterprise budgets as shown in Appendix Tables 1 to 7 for the different treatments in Table 1.1. Gross margins cover selected cash expenses such as seed costs, fertilizer costs, herbicides costs, tillage costs and custom costs. The budgets omit costs that are unchanging across treatments such as land. Hence, although they do not fully measure profitability, they offer a complete measure of profitability differences across treatments. For Treatment 4, the no chemical treatment, two enterprise budgets were constructed, one assuming non-organic prices and the other assuming certified organic farm prices.

1.6.1.1 Relative Profitability

Among the cropping systems, the comparatively more profitable would always be preferred by a profit maximizing producer. Thus, selecting the optimal technology involves two stages: computing the profit for each treatment, t, then comparing across the T number of treatments.

Mathematically, profitability across is given by:

$$\pi_t = p_Q.Q(t|x_E, x_P) - c(t|p_x) - c_0 \quad (4)$$

Where π is the profit or the revenue above selected costs. Q is the output which is a function of treatment, t, conditional on factors that contribute to output such as input used which includes both the polluting and environmental enhancing inputs, x_P and x_E. c is the variable which accounts for the costs that vary, which is a function of production technology or treatment, t, conditional on input prices, p_x. While c_0 accounts for the fixed costs which are the same for the treatments.

1.6.1.2 Crop Prices and Sensitivity Analysis

Choi and Helberger (1993) looked at how sensitive are crop yields to price changes and farm programs. Moreover, Houck and Gallagher (1976) using time series for 1951-1972 estimated the corn yield changes with respect to changes in corn price.

In this paper, we also look at the sensitivity of profitability changes in response to changes in crop prices. A reasonable time series price data from National Agricultural Statistics Service (NASS) was used (1978-2008). Crop prices were deflated to year 2008 using the 2008 Economic Report of the President for the producer price index for farm products.

Standard deviations were computed to determine a low price scenario, and a high price scenario relative to the baseline. The low price scenario is computed by subtracting the computed standard deviation from the baseline price while the high price scenario is computed by adding the computed standard deviation to the baseline price.

Thus, expected profit can be written in terms of both price scenario, j, and technology treatment, t,

$$\pi_{tj} = p_{Qj} . Q_t(t|x_E, x_P) - c_t(t|p_x)] \quad (5)$$

where subscript j represents the price scenario (low, mean, or high price scenario).

1.6.2 Trade-Off frontiers and Efficiency Determination

This study illustrates the tradeoffs between the economic and environmental sustainability of different agricultural systems. The joint distribution of outcomes is presented in a graphical form with environmental measures on the y-axis and revenue over selected costs or gross margin on the x-axis. A given point on the graph represents the joint environmental-economic outcome for a given type of technology or cropping system adopted. Each different KBS-LTER treatment (conventional, no-till, low-input, organic, alfalfa, poplar and successional plots) generates a new point. Connecting the points via ideal point method (IPM) forms a frontier.

Using IPM idea, we look for at least one point that dominates the other points. Generally, along the frontier, the idea is that gains in one area cause losses in the other one. If there is a win-win situation, then one of the points must have been inefficient. As we can recall in previous section, the tradeoff curve represents the joint distribution of economic-environmental outcomes that are efficient.

1.7 Results and Discussion

Appendix Tables 1 through 7 present the enterprise budgets for the different treatments presented in Table 1.1. The information is summarized in bar charts in Figures 1.3 and 1.4 where revenue above selected costs and gross revenue vis-a-vis costs across treatments are presented. The no chemical or "organic" treatment under certified organic selling prices generated the highest revenue followed by the no-till treatment, the low input treatment and the conventional treatment. Organic prices have been high, thus generating highest profits. When the same treatment was evaluated using non-organic prices, the profit was lowest among the four cropping systems. This could be explained by the low yield performance of this treatment. The mean yields in Figure 1.5 show that the organic treatment did not perform well for corn, soybean or wheat. No-till performed best in yields followed by low input and conventional treatment. Thus, at non-organic selling prices, the no-till treatment generated the highest profit. An interesting issue is given the profitability of organic treatment with large premium, Michigan Department of Agriculture reports that only 140 farms out of 53,000 farms across the state are currently certified as organic farms under USDA's National Organic Program, which is less than 1% of all Michigan farms.[6] One possible reason why more farmers are not adopting organic practices is the transaction and time cost of procuring a certification. During the three-year adjustment, farmers suffer lower yields without higher prices. Moreover, if most farmers switch to organic farming, the large price premiums might cease to persist.

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[6] Sattleberg, J. 2008. "Getting to Organic."
http://74.125.95.132/search?q=cache:zh8DUGkYZdUJ:www.moffa.org/f/Getting_to_Organic_2008.pdf+organic+farmers+in+michigan&cd=11&hl=en&ct=clnk&gl=us

Figure 1.6 shows a stacked bar graph of proportion of inputs by treatment. Tillage cost was high for the organic treatment and low input treatments. While chemical cost was highest for the no till treatment, the low input treatment had low cost on agrichemicals but had the highest cost for tillage due to reliance on tillage for weed control. The no-till treatment had zero tillage cost but the highest agrichemical cost for weed control. Figure 1.6 shows that there are increased herbicide costs with the no-till treatment. Thus, a no-till budget may appear less expensive in terms of tillage costs, but agrichemical costs are increased.

The annualized revenue and costs for the perennial systems, alfalfa and poplar, are also included in the analysis. Looking at the stacked bar graph on proportion of input costs, alfalfa generated the highest custom costs, like hay baling, but all in all annualized total costs for other things are low for alfalfa and poplar. Annualized revenue for poplar and alfalfa were also low.

The effects of changes in crop prices are also subjected to crop price sensitivity analysis, as shown in Figure 1.7. This shows how changes in crop prices could impact profitability. With this fact in mind the study calculated the net return for three different price scenarios (high, mean and low) by taking the average of the deflated prices from 1978-2008 and computing standard deviations from the actual prices observed presented in Appendix Table 8. Ranking of systems by relative profitability does not seem to change regardless of crop price scenario. This shows that ranking is robust to output prices making the information meaningful for managerial decisions.

Table 1.4 summarizes the revenue above selected costs together with environmental indicators namely, global warming and nitrate leaching. Figures 1.8 and

1.9 show the plotted points and estimated tradeoff frontiers between nitrate leaching and revenue above selected cost and between GWP and revenue above selected costs, respectively.

By using the efficiency criteria discussed earlier, we know that the ideal direction for both environmental indicators would be moving toward southeast direction in both XY space as indicated by the arrow on the lower right of the diagram. That is because moving towards that direction would mean improved profits and less negative environmental effect.

By selecting efficient points we see that in Figure 1.8 for global warming potential as environmental indicator, alfalfa and certified organic treatments dominate the rest. Anything lying to the left or above that solid line is dominated in the sense that there is a chance to increase the profit or decrease negative environmental effects or both by moving towards the frontier. Excluding the certified organic prices from the analysis yields a different frontier which includes no till and alfalfa, as shown by the dashed line. The slope for the dashed tradeoff frontier is steeper than the tradeoff frontier with a solid line which implies that the farmer can improve GWP at a lower unit cost in reduced profitability.

Regarding the nitrate leaching, the certified organic and no-till treatments dominate the rest as shown by the solid line in Figure 1.9. Excluding certified organic yields a tradeoff frontier that only includes only the no-till treatment. In this case, no-till treatment is a corner solution meaning one technology exists in the efficient set.

1.8 Summary and Conclusion

In both the trade off frontiers, the conventional treatment is dominated. Also, the organic treatment is dominated unless certified organic prices are used. This shows that the conventional treatment is a dominated choice, which leads to the question of why farmers are still using this technology. Based on the trade off frontiers, the no-till cropping system shows a potential as an efficient choice for the farmer. With the method presented in this study, it was shown that tradeoffs exist as farmers make choices between environmental and economic goals. Trade-off curves represent a convenient means of summarizing the information for policy makers and form the basis for conceptualizing sustainability policies.

Table 1.1 Description for the Different Treatments at KBS-LTER

Treatment	Description
Conventional	Standard chemical input CSW rotation, chisel plowed
No-Till	Standard chemical input CSW rotation no-tilled
Low Input	Low chemical Input CSW rotation conventionally tilled (ridge till for 1993), with Cover Crops, banded herbicide, starter N at planting, additional post plant cultivation
Organic	Zero chemical input CSW rotation conventionally tilled (ridge till for 1993), With Cover Crops, additional post planting cultivation (rotary hoe)
Poplar	Populous clones on Short Rotation (9-10 years) harvest cycle
Alfalfa	Continuous Alfalfa, replanted every 6-7 years

Source: KBS-LTER Website, http://lter.kbs.msu.edu/about/experimental_design.php

Table 1.2. Input Prices and Sources

Input	Price	Unit	Source
Corn Seed	$ 111.00	per 80000 kernels	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Soybean Seed	$ 27.60	bu	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Wheat Seed	$ 7.30	bu	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Red Clover Seed	$ 174.00	cwt	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Organic Corn Seed	$ 2.95	per 200 seeds	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Organic Soybean Seed	$ 32.00	bu	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Organic Wheat Seed	$ 0.30	lb	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Poplar Cuttings	$ 0.22	cutting	Average price cited by nurseries in Great Lakes Region; University of Minnesota recommendations, April 2008; http://www.cinram.umn.edu/newsletter/Poplar-Profits.htm
Alfalfa Seeds	$ 4.50	lb	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Nitrogen	$ 0.71	lb	Average price cited by agricultural input supply company in Michigan, i.e. Jorgensens; March 2008
Phosphorus	$ 0.89	lb	Average price cited by agricultural input supply company in Michigan, i.e. Jorgensens; March 2008
Potassium	$ 0.55	lb	Average price cited by agricultural input supply company in Michigan, i.e. Jorgensens; March 2008
Pesticides	varies	varies	Average price cited by agricultural input supply company in Michigan, i.e. Jorgensens; March 2008
Cost of Certification of an Average Size Farm	$ 9.43	per acre	Ferguson, 2004; Organic Certification Procedures and Costs
Machinery - Custom Costs	varies	varies	Stein, 2008 Machine Work Rates for Saginaw MI and Iowa State , 2008, Iowa Custom Rate Survey

Table 1.3. Output Prices and Sources

Output	Price	Unit	Source
Corn	$ 2.66	bu	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Soybean	$ 6.09	bu	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Wheat	$ 3.29	bu	NASS 2008 Agricultural Statistics Report, http://www.nass.usda.gov/QuickStats/index2.jsp
Organic Corn	$ 3.01	bu	ERS-USDA Average Organic Prices 2008, http://www.ers.usda.gov/Data/OrganicPrices/
Organic Soybean	$ 12.29	bu	ERS-USDA Average Organic Prices 2008, http://www.ers.usda.gov/Data/OrganicPrices/
Organic Wheat	$ 5.49	bu	ERS-USDA Average Organic Prices 2008, http://www.ers.usda.gov/Data/OrganicPrices/
Price Deflator	-	-	Price was deflated to 2008; Whitehouse Economic Report; http://www.gpoaccess.gov/eop/tables08.html
Alfalfa Hay	$ 39.00	ton	Center for Dairy Profitability, 2008, Crop Enterprise Budgets, http:www.cdp/wisc.edu
Poplar Wood	$ 45.00	ton	Average price cited by nurseries in Great Lakes Region; University of Minnesota recommendations, April 2008; http://www.cinram.umn.edu/newsletter/Poplar-Profits.htm

Table 1.4 Mean Values forRevenue Above Selected Costs and Different Environmental Indicators

Treatment	Revenue Above Selected Costs ($/acre)	Nitrate Leaching (Mean kg No3-N/acre)	Global Warming Potential (g of carbon dioxide equivalents/m-2)
Conventional	122	6.07	114
No-Till	140	-1.54	14
Low-Input	134	0.12	63
Organic in Non-organic Prices	83	0.12	41
Organic in Organic Prices	182	0.12	41
Poplar	18	0.07	-20
Alfalfa	36	1.09	-105

Sources: Revenues and costs from enterprise budgets; environmental indicators from G.P. Robertson et al (2000), Syswerda (2009)

Figure 1.1 Production possibilities frontiers with profits and environmental quality and indifference curves for Farmer *i*

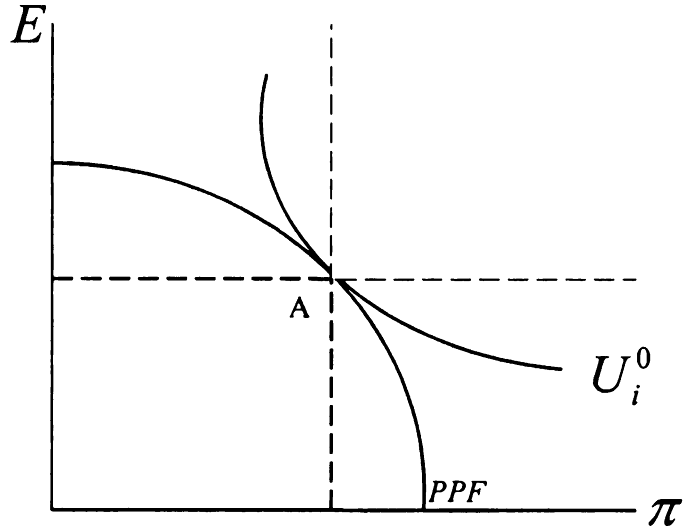


Figure 1.2 Production possibilities frontiers with profits and environmental damage and indifference curve for Farmer i

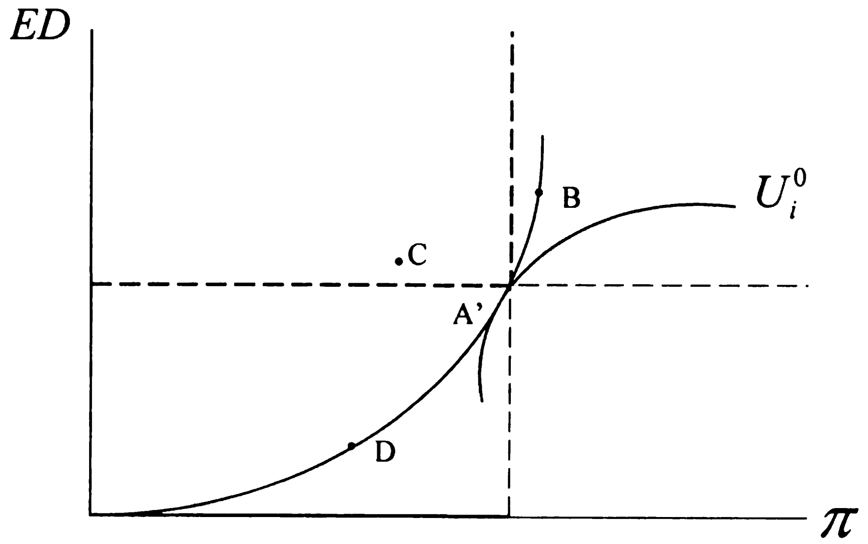
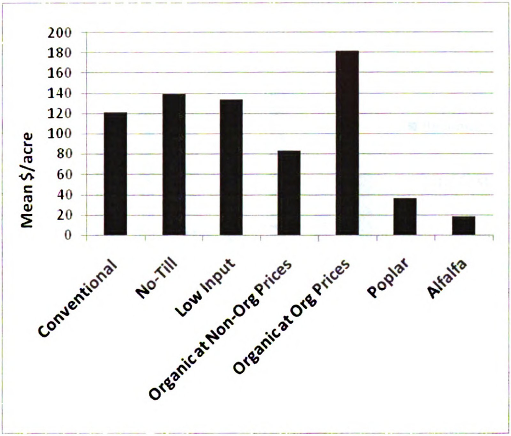
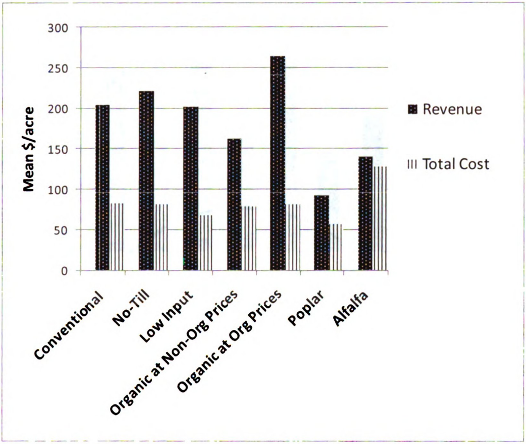


Figure 1.3 Mean revenue above selected costs across treatments, KBS-LTER, Hickory Corners, Michigan, 1993-2007*



* Except for alfalfa:1989-2004; poplar:1989-1998.

Figure 1.4 Mean revenue and costs that vary across treatments, KBS-LTER, Hickory Corners, Michigan, 1993-2007*



* Except for alfalfa:1989-2004; poplar:1989-1998.

Figure 1.5 Mean yields for corn, soybean and wheat in the annual cropping systems, KBS-LTER, Hickory Corners, Michigan, 1993-1997

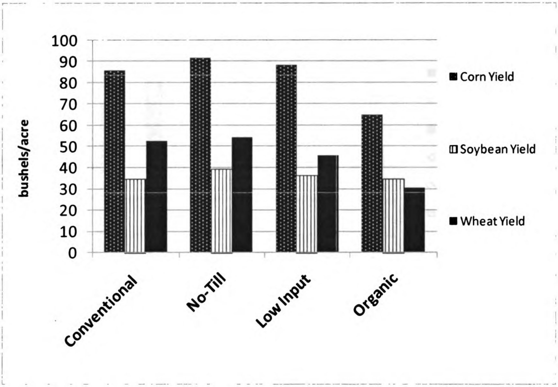
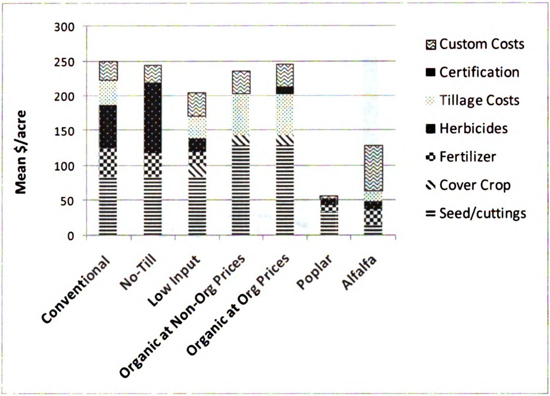


Figure 1.6 Proportion of inputs by cropping system, KBS-LTER, Hickory Corners, Michigan, 1993-1997*



* Except for alfalfa:1989-2004; poplar:1989-1998.

Figure 1.7 Sensitivity of profits based on crop prices for the annual cropping system treatments, KBS-LTER, Hickory Corners, Michigan, 1993-1997

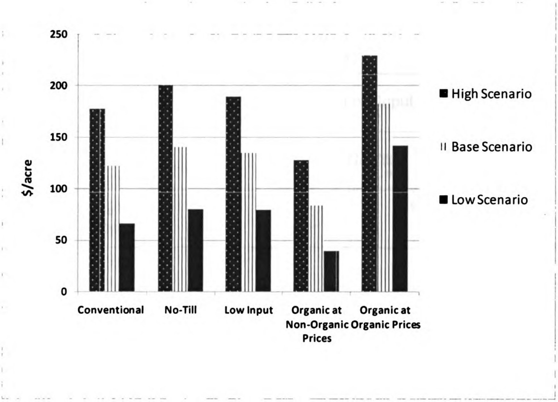
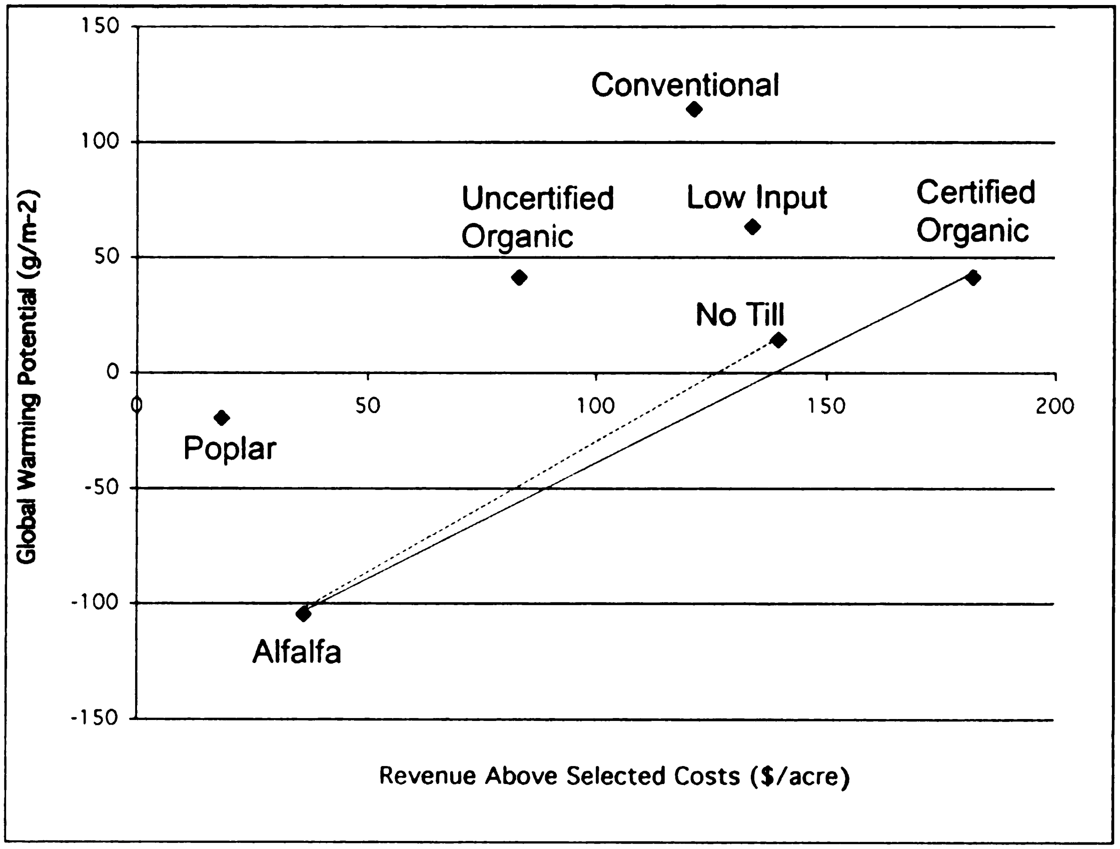
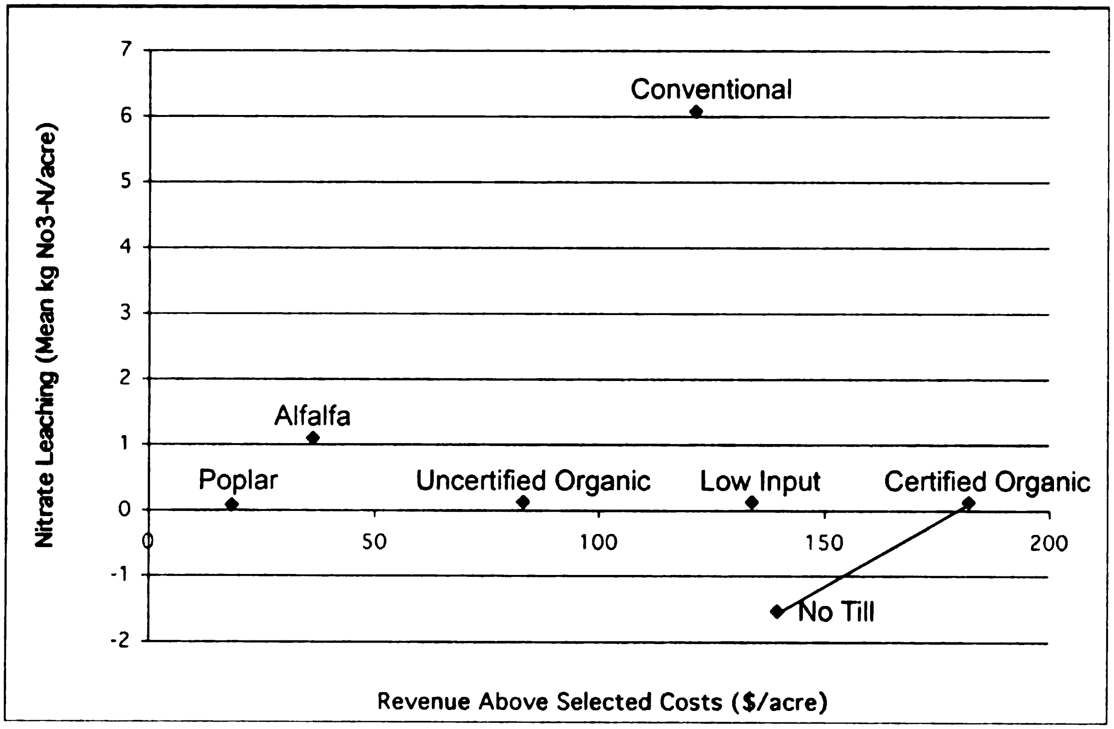


Figure 1.8 Tradeoffs between Global Warming Potential and revenue above selected costs, KBS-LTER, Hickory Corners, Michigan, 1993-2007*



* Except for alfalfa:1989-2004; poplar:1989-1998.

Figure 1.9 Tradeoffs between nitrate leaching and revenue above selected costs, kbs-lter, Hickory Corners, Michigan, 1993-2007*



* Except for alfalfa:1989-2004; poplar:1989-1998.

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Essay 2:
Incentives to Supply Enhanced Ecosystem Services from Cropland

2.1 Introduction

Agriculture is a managed ecosystem. The decisions of its managers drive the mix of ecosystem services that it produces. Farmers play an important role as ecosystem managers in that they balance their decisions regarding land and other agricultural inputs for production and modify their practices to adjust the positive and negative impacts to the environment (Wossink and Swinton, 2007). By their choices of production inputs and management practices, farmers shape their impacts on the environment. Thus, agriculture offers a special opportunity for ecosystem service management because ecosystem services are produced simultaneously with agricultural products.

The policy challenge is to develop incentives for farmers to produce ecosystem services while meeting the demand for food (Hodge, 1991; Hanley and Oglethorpe, 1999). Important policy questions from this growing body of research are:

- What are the incentives that will make the farmers provide ecosystem services?
- Are farmers willing to change their land management practices in exchange for a payment, and if so, how much?
- Which farmers are willing to change their practices and should future policies be targeted toward specific groups of farmers?

The literature concerning what motivates producers to adopt environmentally sound practices has been growing. Empirical studies of conservation farming have found that the most important motives for conservation adoption are "selfish", financial-economic concerns (Chouinard et al, 2006). Cary and Wikinson (1997) showed that the best way to increase the use of conservation practices is to make them profitable. However non-financial factors also play a role in conservation decisions because producers may gain direct personal satisfaction from the improved environmental quality (Chouinard et al, 2006).

Understanding crop farmers' willingness to supply nonmarketed ecosystem services calls for understanding the effects of changed cropping systems on both profit and personal satisfaction. The late 1990s saw the emergence of literature on the supply side of environmental improvements from agriculture (Bonnieux and Rainelly, 1995; Bateman et al, 1996; Kazenwadel et al., 1998). These authors focused on the farmers' willingness to adopt new practices and on the factors influencing their participation decisions. Some studies were based on actual scenarios and some were based on contingent data or hypothetical scenarios. For example, Purvis et al (1989) studied farmers' willingness to participate in a filter strip program using a contingent valuation survey. The study concluded that farmers' participation decisions are determined by the yearly payment offered to participants, farmers' perception on environmental change, and their opportunity costs. For example, farmers would be more likely to participate in a filter strip program if the rules allow haying or other economic uses of the enrolled cropland.

This study also uses stated preference survey methods, but it differs from the others in three major respects. First, it takes into account the potential that the attitude and behavior of farmers are influenced not only by farmer and farm characteristics, but also by the characteristics of the required practices or cropping systems. This implies that participation could vary across different types of programs. In order to test this, we evaluated the behavior of the same group of respondents toward four different sets of distinct cropping practices. Second, the paper introduces a subsidy program to make direct payments to the farmers for adopting cropping practices that are known to produce environmental services rather than as a cost sharing program. Finally, this analysis goes beyond participation to address acreage enrollment. In so doing, it becomes possible to estimate farm-level supply functions for land providing specified suites of ecosystem services.

2.2 Objectives of the Study

The objectives of this paper are: (1) to identify farmer willingness to adopt environmental stewardship practices in exchange for payment (willingness to accept or WTA) to; (2) to investigate the determinants of their willingness to adopt those practices and the relative importance of these factors; and (3) to estimate empirical supply curves for acreage enrollment for hypothetical environmental stewardship programs that correspond to ecosystem service levels that could be produced.

The rest of the paper is organized in two broad sections. The next section introduces the conceptual framework, the research design and the methods of data collection and analysis. The final section summarizes the findings and discusses their policy implications.

2.3 Conceptual Model: The Supply of Environmental Services by Farm Households

2.3.1 Multi-attribute Utility Function

A basic premise of the neoclassical economic theory is that rational producers make choices about production inputs and technology (e.g. cropping practices). Following Dupraz et al (2003), farmer behavior is motivated by utility maximization, where utility is increasing in consumption goods and environmental services. Consumption is constrained by net income, which depends on agricultural product revenue minus costs. Thus, farmer behavior can be formalized as follows:

$$\underset{g,es}{Max}\, U(g, es) \qquad (1)$$

$$g \leq \pi(p, es) + NFI \qquad (2)$$

$$es \geq 0 \qquad (3)$$

The parameters of the utility function are household consumption denoted by g and the quantity of environmental service, es, that is co-produced by farming activities. The utility function is assumed to be increasing, concave and differentiable in g and es. The household consumption goods, g cannot exceed the sum of the farm income, $\pi(p, es)$, and exogenous non-farm income, NFI. The profit function, $\pi(p, es)$, is assumed to be convex and is a function of prices of factors and products, p and environmental service, es. The solutions to this utility maximization model are denoted as: g^*, es^* and $g^*, es^*, U^* = U(g^*, es^*)$.

From equations 1 and 2, we see that apart from marketed agricultural products, two kinds of ecosystem services, ES, matter in this model: ES in the utility function and supporting ES in the profit function that substitute for cash inputs in the agricultural production (e.g., soil quality, biological control of crop pests). Thus we expect the demand for these supporting ES to be a derived input demand for ES that depends upon the prices of products and inputs.

2.3.2 Economic model of Willingness to Accept and Environmental Supply

The microeconomic concept of "willingness to accept" (WTA) is helpful to specify the supply of environmental service. WTA is defined as the minimum amount of income that the farm household would require to supply a given amount of environmental service. WTA is classically formalized by using an expenditure function to provide theoretical structure for welfare estimation. WTA can be represented as the change in expenditure levels of the farm household in response to change in the level of ecosystem services produced, given that their utility is kept the same.

Following Dupraz et al's (2003) derivation for the definition of WTA, we assume that the farmer is invited to increase the environmental service supply, es, by a fixed quantity such that: $\Delta es = es_1 - es_0 > 0$. The expenditure function, $e(p, es, U_0)$, represents the minimum amount of exogenous income which in this case is represented by , $NFI = g - \pi(p, es)$, that is needed to produce a fixed quantity of ecosystem service Δes while maintaining constant utility. Specifically,

$$e(p, es, U_0) = Min[g - \pi(p, es); U(g, es) \geq U_0] \quad (4)$$

$$WTA = e(p, es_1, U_0) - e(p, es_0, U_0) = e(p, es_1, U_0) - e_0 \quad (5)$$

where equation 5 expresses the minimum payment that the farmer requires to increase ES production from es_0 to es_1, while maintaining utility level U_0. Letting $g^*(p, es, U_0)$ denote the solution of the cost minimization problem in equation 4, the expression in equation 5 becomes:

$$WTA = [\pi(p, es_0) - \pi(p, es_1)] - [g^*(p, es_0, U_0) - g^*(p, es_1, U_0)] \quad (6)$$

The first term in brackets in equation (6) is the farm's foregone profit. The second term is the amount that the household is willing to pay for an increase in environmental service. In other words, the willingness to accept equals the foregone profit offset by the monetary value of change in the farmer's utility from producing more ecosystem service. This equation can be restated as:

$$WTA = [\pi(p, es_0) - \pi(p, es_1)] - MVU(p, es_1), \quad (7)$$

where the function *MVU*(.) represents the monetary value of the utility from switching from the current technology to the alternative technology. This variable shows the utility from producing more ecosystem service expressed in monetary terms via consumption goods.

The changes in expenditure for changes in ecosystem services, $\frac{\partial e^*}{\partial es}$, traces out the farmers supply function for the non-marketed ecosystem service. The area below the supply curve represents the WTA to produce ecosystem services under any given technology.

2.3.3 The Farmer's Decision Rule

In this study, farmers were not directly asked the minimum amount they would be willing to accept in order to adopt certain cropping systems. Rather they were asked how many acres they would enroll in a program that offers to pay "*s*" dollars per acre and requires them to adopt a set of practices known to produce ecosystem services at some transaction cost involved with participation, denoted *TC*. Thus, the net payment to farmers for enrolling "*a*" acres in the program is $sa - TC$.

The logical condition for farmer enrollment behavior is that for any per acre payment, s, farmers with WTA less than or equal to the net payment from participation are willing to participate in the program (implying $a > 0$), and those with WTA greater than net payment from participation are not willing to participate. Based on the definition of WTA in equation (7), this participation condition can be written:

$$a > 0 \quad iff. \;\; [\pi(p, es_0) - \pi(p, es_1) - MVU(p, es_1)] \leq sa - TC \qquad (8)$$

Now, consider a farmer that manages N total acres. Let es_1 correspond to the ecosystem service produced from some portion of land, a out of N acres, that is devoted to an alternative cropping system Q', and let es_0 correspond to the initial level of ecosystem service produced from devoting all land, N, to the initial cropping system Q^0. Transforming the equation into an acreage based decision model that allows farmers to allocate their land to a hypothetical program that requires them to do a particular cropping system, equation 8 could be rewritten as:

$$\pi(N, Q^0) \leq \pi(N-a, p, Q^0) + \pi(a, p, Q') + sa + MVU(Q', Z) - TC(a, Z) \quad (9)$$

where π is the profit function; N is total land acreage that the farmer manages; a is the amount of land allocated to production under an alternative technology or cropping system where they are given a subsidy or payment per acre, s. The function, $Q^0 = f(S, es_0, Z)$, is the currently employed production technology, which depends on a combination of systems in the vector S which conditions the choice of inputs in the production function, ecosystem services, *es*, and farmer/farm characteristics *Z*. The combination of system, *S*, entails crop choice, rotation tillage, fertility and pest management. *Z* is a vector of parameters that captures characteristics of the farmer that govern his or her preferences for environmental benefits, but also farming experience and willingness to adopt new technologies such as age and education. On the other hand, $Q' = f(S', es_1, Z)$ is an alternative production technology that depends on some other combination of systems thus defining a new set of inputs and new outcome level of ecosystem services; while $TC(a, Z)$ captures various transaction, monitoring and enforcement costs related to participation in the payment for environmental services program that effectively reduce the total size of the subsidy.

The right hand side of equation (9) corresponds to the farmer's profit from re-allocating a acres of land to an alternative technology under the subsidy scheme: the first term is the profit generated from $N - a$ acres under the current technology; the second term is the profit generated from a acres under the alternative technology; the third term is the effective (or expected) subsidy payment; and the fourth term is the monetary value of utility from switching to an alternative technology; and the fifth negative term is the transaction costs, TC . The left hand side of equation (9) is simply the farmer's profit under the current technology. Thus, the farmer will have an incentive to allocate land to an alternative land-management system if the combined benefits under the subsidy scheme are valued at least as much as the farmer's current profit.

This decision rule takes into account not only direct costs but also the opportunity cost of deviating from profit maximizing mix of inputs. The farmer's preferences and resource constraints also affect this decision. Thus, participation depends on the cropping systems' relative profitability (Valentin et al., 2004), transaction costs of being involved in the program and general attitudes towards adoption (McCann and Easter, 1999).

2.4 The Data

2.4.1 Data Collection

The study asked farmers about their willingness to adopt selected practices from corn, soybean and wheat cropping systems related to ones studied by scientists since 1989 at the long-term ecological research project in agro-ecology at the Kellogg Biological Station (KBS-LTER) near Kalamazoo, Michigan. The payment vehicle drew upon traits of existing U.S. farm programs that pay farmers for providing environmental services. Specifically, the questionnaire offered respondents specified payments if they would participate in a hypothetical farm program that paid them by the acre to adopt specified cropping practices. Farmers who expressed willingness to participate were asked how many acres they would enroll in the program.

The data on farmers' potential supply of enhanced ecosystem services was collected using a mail survey sent to a random sample of 3,000 corn and soybean growers in Michigan in mid-February of 2008. The survey used a four contact version of the tailored design method (Dillman, 2000) consisting of 1) a prenotice letter, 2) a questionnaire and one dollar incentive, 3) a postcard reminder, and 4) a replacement questionnaire. The survey achieved a net response rate of 56.4% after adjustment for refusals, undeliverables and deceased recipients (details in Appendix 8). The survey design and questionnaire development were preceded by a series of farmer focus groups and pre-tests to ensure validity and clarity of the questions as well as an appropriate range of payment offers for those cropping practices. Six farmer focus groups were conducted during February and March of 2007, while in-person questionnaire pre-tests were conducted in January of 2008.

The sample was obtained from the 2007 agricultural census mailing list of the National Agricultural Statistics Service (NASS) office in East Lansing, Michigan. NASS provided the project with a 4-tier, acreage-stratified random sample of 3,000 corn and soybean farmers in Michigan. The four strata represent farmers with 0 to 100, 101 to 500, 501 to 1000 and 1000 and more acres. This method was chosen to allow for comparison across strata to ensure that the farmer population is well represented and that it is linked to the behavioral model on acreage based decision of farmers. In the analyses that follow, weights were used to appropriately correct for the stratification (see Jolejole, 2009, Appendix Table 9).

2.4.2 The Questionnaire Design

The survey instrument presented farmer respondents with a series of four corn-soybean-based cropping systems. The four systems differ in their degree of cropping practices involved, offering increasing levels of ecosystems services compared to a baseline corn-soybean system. The first, System A, was a corn-soybean crop rotation with chisel plow tillage, pre-sidedress nitrate test in corn, and all agrochemicals broadcast in the field according to Michigan State University recommendations or pesticide label instructions. System B was identical except that a cover crop was added during winter. System C added winter wheat to the crop rotation after soybean, in addition to the winter cover crops after corn and wheat. Finally, System D was identical to System C except that fertilizers and pesticides were applied in bands over the row resulting in a 1/3 reduction in chemical applications. Table 2.1 presents the specific practices for each cropping system.

An orthogonal design framework was constructed to combine the various program attributes and payment levels for the cropping systems into different questionnaire versions (Jolejole 2009, Appendix 5). There were six variables: sequence of cropping systems, payment provider, and the four cropping systems described above, each with 4 levels of prices. The design resulted in 16 versions of the questionnaire, which were randomly assigned within each stratum (details in Jolejole 2009, Appendix 6). The payment levels for each of the cropping systems were set by deriving the bids associated with the 20^{th}, 40^{th}, 60^{th} and 80^{th} percentiles of the distribution of participation predictions that were computed from pilot models that used data from the farmer focus groups held in 2007. Other factors that varied in the framing of the proposed transaction were the payment provider (government or non-government organization) and the sequence of cropping practice questions presented (increasing effort [from system A to D] or decreasing effort [from system D to A]).

Respondents were asked a variety of attitudinal and background questions in order to assess farmer preferences about the environment, the cost of changing practices, and levels of household and farm resources, (Jolejole 2009, Appendices 3 and 7). The stated preference questions were preceded by a full description of how the program works along with instructions on what varied across the questions. The enrollment question was presented as follows: "If a program run by [the government or a non-governmental organization] would pay you $[X] per acre each year for 5 years for using cropping system [Y], how many acres of land would you enroll in this program? (If you would not enroll, please write zero)." Terms in square brackets were varied across questionnaire versions.

2.5 Methods

2.5.1 Econometrics of WTA

Farmer respondents were asked to make two decisions with regard to their willingness to accept payments to adopt environmental stewardship cropping systems: (1) Will they participate in the program? (2) If yes, how much of the land area will they devote to environmental stewardship? The econometric hurdle model allows for the possibility that these two decisions are affected by different sets of variables.

The model, originally due to Cragg (1971), has been applied in a variety of areas. Applications include Burton, Dorsett and Young (1996) and Newman (2001), who modeled household expenditure on meat; Jensen and Yen (1996) who modeled U.S. food expenditure outside the home; Yen (1997) who applied the model to alcohol consumption and Jones (1997) who examined U.S. household consumption of cheese. The model has rarely been used in willingness to accept studies. Some exceptions would be Goodwin et al. (1993), Yen et al. (1997) and Reiser and Sheeter (1999).

The hurdle model is a parametric generalization of the tobit model, in which the decision to participate in the program and the level or degree of participation (e.g., acreage enrollment) are determined by two separate processes. This approach allows the two decisions to have different variables or different coefficients with the same variables. This study employs a hurdle model where the probability of participation in the program is estimated as a separate function from the number of acres supplied. The two stages of the hurdle model will be called the participation model and acreage decision model, respectively.

A probit model is used to estimate the initial participation decision. The probit relates choice probability to explanatory factors the program, farm, and farmer characteristics. We let α stand for acres enrolled. The following probit model is used to estimate the probability of participation (i.e., $\alpha>0$):

$$\Pr(\alpha > 0|x) = \Phi\left(\frac{\beta'_{\rho} x_i}{\sigma}\right) \qquad (10)$$

where $\Phi(.)$ is the standard normal cumulative distribution function, x_i is an $S \times 1$ vector of farm and farmer characteristics for farmer i, and β_{ρ} is the vector of coefficients from the participation model and standard deviation, σ_{ρ}.

The second step of the hurdle is a truncated regression model to account for the acreage enrollment conditional on participation. We first assume a latent acreage variable α_i * that is generated by:

$$\alpha_i^* = \beta'_\alpha x_i + \varepsilon_{\alpha i} \qquad (11)$$

where x_i is a $S \times 1$ vector of farm and farmer characteristics for farmer i, and β_α is the vector of coefficients for acreage decision and $\varepsilon_{\alpha i}$ are disturbance terms from acreage decision assumed to be independently and normally distributed with mean zero and variance σ_α^ρ.

We observe enrolled acres α_i only if $\alpha_i^* > 0$ so that the expected value of acres is,

$$E(\alpha_i | \alpha_i > 0) = \beta'_\alpha x_i + \sigma\lambda(\gamma) \qquad (12)$$

where

$$\lambda(\gamma) = \frac{\phi(\gamma)}{1 - \Phi(\gamma)} \text{ and } \gamma = \frac{-x\beta_\alpha}{\sigma} \qquad (13)$$

where $\phi(.)$ is the standard normal probability density function and $\Phi(.)$ is the standard normal cumulative distribution function. Equation (13) is the truncated regression for positive values of the continuous decision of how many acres to enroll $(\alpha > 0)$. Note that for observed acres,

$$\alpha_i = \alpha_i^* \mid \alpha_i^* > 0 \sim \text{Truncated Normal.} \qquad (14)$$

The hurdle model allows the participation decision and acreage enrollment decision to have different coefficients, i.e. coefficients in equations 10 and 12 are different because they arise from separate stochastic models. If they are the same, then a tobit model arises (Lin and Schmidt, 1984). The truncation correction accounts for the fact that only a portion of the distribution is observed (i.e. only the participants), and, therefore, the mean is only calculated based upon what is observed, i.e. participation.

The results from both probit and truncated regressions are important in predicting acreage enrollment, i.e., estimating the supply of land contributing ES. The acreage supply prediction can be computed by multiplying the probability of participation (Equation 10) by the predicted acreage conditional on participation (Equation 12):

$$PREDICTACRES = \Pr(\alpha_i > 0 \mid x) * E(\alpha_i \mid \alpha_i > 0) \quad (15)$$

The predicted supply of land contributing ES is traced by systematically increasing the payment variable upward from zero while holding other variables at their mean values.

2.5.2 Variable Specification and Working Hypotheses

For the participation model, a dichotomous dependent variable for participation indicates whether or not a farmer is willing to accept the offered payment to adopt the environmentally friendly practices (participation=1, nonparticipation=0). For the acreage model, a continuous dependent variable measures the number of acres that the farmer agreed to enroll.

The independent variables are hypothesized to be associated with the adoption of environmentally friendly measures that implicitly links to prior studies on the theoretical derivation of WTA in Equation (11), and the particularity of the farming systems of the study area. The potential explanatory variables that are hypothesized to influence farmers' willingness to adopt to environmental measures are the following:

Payment or subsidy (s). The adoption of changed cropping practices is assumed to cause the farmer to incur additional costs for labor and/or material inputs. As a result, subsidy payments to farmers to adopt stewardship measures are expected to have a positive effect on participation.

Descending sequence. The cropping systems differed in their degree of changes relative to a typical corn-soybean rotation. This variable is a dummy variable that accounts for the manner the cropping systems were presented. (1-descending sequence and 0-ascending sequence) This accounts for the "anchoring effect" of questionnaire versions. Previous studies suggest that it is ideal for this variable to have no effect on participation decision.

Government. This variable is a dummy variable which accounts for the payment mechanism (1-government and 0-non-governmental organization). It might reflect perceived transaction costs involved in participation. One person in the farmer focus groups was adamant that farmers have a higher transaction cost when dealing with the government. It might also measure aversion to government programs or a general political philosophy. Thus, this variable is expected to have a negative effect on participation.

Perceived Environmental Improvement (Monetary Value of Utility from Ecosystem Services, MVU). This variable was measured through a series of 5 point Likert scale questions (1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree) that measure how much the farmer perceives that the proposed cropping system would outperform their current system in terms of environmental qualities such as soil organic matter, soil conservation, phosphorus surface runoff, nitrate leaching, global warming potential and pesticide risk. The answers for all these environmental services were averaged to derive one variable to measure perceived environmental improvement offered by each cropping system. Lynne et al., (1988) suggest that while economic incentives will increase effort, responsiveness will differ with strength of conservation related attitudes and perceptions. Other empirical studies show that farmers with a generally positive attitude towards new technologies are keen on undertaking and maintaining environmental measures (Shiferaw and Holden, 1998; Abera, 2003). Also, according to a paper by Bonnieux (1998), positive environmental attitude influence adoption of conservation practices. Hence, in this study, a high value of perceived environmental improvement is hypothesized to have a positive effect on participation.

Total Land Area Managed (N) refers to the total area of cropland managed by the farmer at the time of the survey. Empirical studies have found that large farms are more likely to use conservation technology than small farms (Norris and Batie, 1987; Bekele and Drake, 2003). Therefore, it is hypothesized that area of the cropland is positively related with participation.

Current Practices ($Q = f(S, es_0, Z)$). This category consists of several variables that show what the farmers are currently doing on their farms. It includes whether they have wheat in rotation, type of tillage they use, and cover crop use. The proposed new practice may involve costs, but if the farmer is currently doing something similar to the cropping system being offered, the marginal cost of participation will be low and it is expected that they will be more likely to participate.

Biophysical variables (part of Z, farm characteristics) in this study refer to dummy variables for soil texture. Clay soils may be more fertile but less well-drained than the loam soil baseline, whereas sandy soils are less fertile but better drained due to loser particles. Biophysical variables have been found to have a mixed effect on the adoption of environmental measures (Ervin and Ervin, 1982; Norris and Battie, 1987; Pattanayak and Mercer, 1998; Pender and Kerr, 1998). Particularly in this study, adoption of cropping system D which requires less use of chemicals is expected to be positively related to clay soil which is classified to be more fertile than sandy soil and silty soil. Cropping system B, C and D, on the other hand, all of which requires the use of cover crops over winter is expected to be positively related to sandy soil.

Future Price Expectations (p, expected output prices). This category includes expected harvest time prices of corn, soybean and wheat. Wheat-to-corn price ratio and wheat-to-soybean price ratios were also derived. Both are expected to be positively related on cropping systems that require wheat, namely cropping systems C and D and may be negative for cropping systems A and B.

Experiential Variables (Environmental Program Experience; part of Z, farm/farmer characteristics). This consists of several dummy variables that indicate any form of experience with the conservation programs, such as Michigan's Agriculture Environmental Assurance Program (MAEAP) and the federal Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP) and the Conservation Security Program (CSP). Empirical studies have shown that prior membership in conservation programs is positively correlated with conservation practice adoption and effort (Ervin and Ervin, 1982; Norris and Batie, 1987; Sureshwaran et al., 1996; Pattanayak and Mercer, 1998; Bekele and Drake, 2003).

Farmer demographics (Z). This category includes farm and farmer characteristics. Dupraz et al. (2000) found that environmental stewardship programs are more likely to be adopted by farmers with higher education. According to Bonnieux (1998), there is a significant age effect, with younger farmers more likely to adopt conservation practices. Drake (1992) stressed that neighboring farms applying environmental measures, older farmers, higher education and previous participation have positive effects on adoption. Vanslembrouck et al. (2002) found that larger farms, agricultural education, participating neighbors and younger farmers are more likely to adopt.

2.6 RESULTS AND DISCUSSION

2.6.1 Descriptive Results

The variables to be included in the regression analysis, their units of measurement and weighted means are presented in Table 2.2. Additional descriptive results are provided in Appendix 10 (Jolejole, 2009). To avoid problems of multicollinearity (Greene, 1997), several variables were dropped from the models, based on F-tests. The final set of variables includes dummies for non-government provider, and descending sequence of cropping system complexity, as well as continuous variables for subsidy payment, perception that the new system being introduced offers more environmental services and total acreage. Other variables included in the analysis are biophysical variables on the most common soil texture for a farm with loam soil as the baseline; current farming practices, including tillage, cover crops and wheat in rotation; expected price of wheat relative to other crops (since wheat is the only crop added in the hypothetical program introduced); experiential variables, and age and education.

Based on the mean values, most of the respondents farm mostly clay soils and practice conservation tillage. Only 9% of the land is planted with wheat and 7% with cover crops. Approximately 15% of the respondents have participated in government programs like EQIP and CRP. Farmers' average age is 54, which is equal to the state average for corn-soy growers (USDA-ERS, 2000).

2.6.2 The Participation Decision

The results of the probit models for adoption of the four proposed cropping systems are presented in Table 2.3. They include parameter estimates, corresponding standard errors and some regression diagnostics. The pseudo R^2 measure of goodness of fit (McFadden, 1973) ranged from 0.18 to 0.26 for the 4 cropping systems. The p-value associated with each coefficient estimate is the probability that the z test statistic would be observed under the null hypothesis that the particular regression coefficient is zero, given the rest of the predictors in the model. The Wald test was used as an alternative to the likelihood ratio test of whether all the predictor regression coefficients in the model are simultaneously zero. For all the models, the null hypothesis that all the regression coefficients are simultaneously zero was rejected.

The results show that the participation decision in all cropping systems is significantly influenced by the payment, perceived environmental improvement from the system being introduced and the total land acreage operated. Hence, farmers are willing to produce ecosystem services at some subsidy. Perceived environmental improvements from the proposed cropping system and greater total land acreage both contribute to willingness to participate, as expected.

Other factors varied in significance depending on which cropping system is offered. Sandy soil is negative and significant for cropping system D as expected.

Moldboard tillage is negative and significant in all cropping systems. The hypothetical program requires chisel plowing. The results suggest that if the farmer is moldboard plowing, he or she is less likely to participate, which likely reflects the fact that switching from one practice to another adds capital costs.

Wheat acres with respect to total land was positive and significant in cropping system C and negative for cropping system A. The ratio of cover cropped land to total land area was positive and significant in cropping system B. These results suggest that if the hypothetical program requires the farmer to do a practice that they already do, they are more likely to participate, which validates the hypothesis we made in the previous section.

The ratio of wheat price to corn price was positive and significant only for cropping system A while wheat price to soybean price was positive and significant for cropping systems B and C. The only result consistent with the previous hypothesis that expected output prices have positive effect on participation would be the positive participation effect on cropping system C.

The USDA Environmental Quality Incentives Program (EQIP) offers financial and technical help to assist farmers to install or implement structural and management practices on eligible agricultural land. Previous experience with EQIP favored participation. This is consistent with the hypothesis that previous experience in similar programs tends to increase participation.

Age was negative and significant for cropping systems A, B and C. This shows that younger farmers are more likely to adopt cropping systems that supply more ecosystem services. The government program provision variable was insignificant for all cropping systems which suggests that farmers do not necessarily view the transaction costs of dealing with the government to be different from those of an unspecified non-governmental organization. The descending sequence variable was negative and significant for cropping systems A and C, which would suggest that farmers are less likely to enroll if the cropping systems are presented in a descending manner. This pattern suggests an anchoring effect.

2.6.3 Acreage Decision

To capture the second decision faced by the farmer on how many acres to enroll in the program, truncated regression is used to model acres supplied conditional on participation in the program. Respondents who did not participate were not included in this regression. Table 2.4 shows the results. The coefficients in the truncated regressions can be interpreted as the change in underlying latent acreage enrollment for every unit change in the variable, and they have a related effect on the conditional acreage amounts (see equation 11).

For all cropping systems, the amount of acreage enrolled is positive and significantly affected by the total land area managed and relative perception of environmental improvement. The payment offer for adopting the cropping systems is significant and positive for cropping systems A, C and D, but somewhat surprisingly, was not significant for system B.

Other factors varied in significance, depending on which cropping system is offered. Sandy soil is positive and significant for cropping systems B and C as expected. Clay soil, on the other hand exhibits a positive and significant effect on acreage offered in all cropping systems. Clay soil's positive effect on cropping system D is consistent with the hypothesis.

Moldboard tillage reduced acreage enrolled in cropping systems A, C and D, while no-till and conservation tillage undermined acreage committed to cropping system A. The proportion of wheat acres with respect to total land increases acreage enrolled in cropping systems C and D. As hypothesized, the more similar the practices in the cropping system offered to the farmer's current system, the more likely the farmers are to participate which is likely due in part to the cost involved in switching to a different cropping system.

The wheat to corn price ratio has a negative and significant effect on acreage enrolled in cropping systems A and B but a positive effect on cropping system D, which is consistent with the hypothesis. Wheat-to-soybean price ratio showed positive and significant effects on acreage enrollment in all cases. The wheat-to-soybean price effect on cropping systems C and D is consistent with the hypothesis.

MAEAP certification had a surprising negative effect on acreage enrolled, although only for cropping system A. MAEAP offers farmers a certification that their crop management practices are consistent with generally approved agricultural practices in the state. The negative sign means that farmers who are MAEAP certified are less likely to enroll acreage in system A.

Farmer age had a negative and significant effect on acreage enrolled in cropping systems A and C. Education on the other hand, increased acreage enrollment in cropping system D. This shows that younger and more educated farmers tend to enroll more acres. The government program provision variable was negative and significant for cropping systems A and D, which suggests that acreage enrollment decreases when the government handles the program. The sequence variable or the way the cropping systems were presented in the questionnaire was insignificant in all cropping systems.

2.6.4 Payment Effects By Stratum

Patterns of participation and acreage enrollment in the environmental stewardship cropping systems program varied significantly by farm size stratum. As mentioned in the previous section, the four strata used include stratum 1 representing the 0-100 acre farms; stratum 2 for 101-500 acre farmers, stratum 3 for 501-1000 acre farms and stratum 4 for farms over 1000 acres.

Table 2.5 shows the participation decision with payment effects by stratum. The stratum dummy equals 1 if the farm is in that size stratum and 0 otherwise. The stratum dummies are interacted with the payment or subsidy variable. On the participation decision, strata 4 and 3 exhibited positive and significant payment by stratum interaction effects in all cropping systems. On the other hand, for stratum 2 the interaction is positive and significant only for cropping systems C and D and for stratum 1 it is insignificant in all cropping systems.

Table 2.6 shows the acreage decision with payment effects by stratum. Strata 4 and 3 exhibited positive and significant payment by stratum interaction effects on the acreage enrollment decision for all cropping systems. On the other hand, in Stratum 2 the interaction is not significant in all cases and in stratum 1 it is negative and significant but only for cropping systems A and B.

An unusual result is the negative and significant effect of payments on the acreage decision for stratum 1 in cropping systems A and B. This means that an increase in payment in cropping system A and B will cause farmers to enroll fewer acres of land. This counterintuitive result may be explained by labor time and physical capital barriers for the small farms to be able to meet the required practices. In many instances, adoption of the proposed practice requires new equipment (e.g., band chemical applicator or chisel plow), which could dramatically increase the marginal cost of increasing acreage on small farms. In other cases, the practice may require new knowledge or added work, which may be too demanding for a part-time farm. Either of these effects could mean that the marginal cost of switching from current cropping system to a new one might be very large for the small farms.

Both the probit and truncated regressions indicate that the payment level strongly affects the participation and acreage decisions only for farms over 500 acres, i.e. strata 3 and 4. Smaller farms do not respond to increasing subsidy levels by increasing acreage enrolled. Again, this may be linked to physical capital and time availability barriers to change from their normal operation.

2.6.5 An Approximation to the Supply Curve

Using the participation and acreage enrollment equations, we adopt the approach of Lee and Helmberger (1985) and McIntosh and Shideed (1989) in predicting program acreage response. The approximated supply curves for acreage enrollment for each cropping system are shown in Figure 2.1. The values used to predict this curve come from the probit and truncated regression results in Tables 2.3 and 2.4 using equation 15. Plotting predicted acreage enrollment for different subsidy levels yields the supply for land for cropping systems that are known to yield ecosystem services.

The first striking pattern in the supply curves is the decline in elasticity with the complexity of the proposed cropping practices. In Figure 2.1, as one moves from Cropping System A (simpler system) to Cropping System D (more complex), the slope of the supply curve becomes steeper, meaning that acreage enrollment becomes less responsive to the increasing payments being offered. This result suggests that more farmers are likely to respond to payment offers for doing cropping system A, which is close to the conventional system and less likely to respond to a payment offer to participate in more complicated cropping system D.

The second striking result is the far greater elasticity of response among larger farms. Figure 2.2, shows the supply curves for acreage enrollment by stratum and cropping system. In all cropping systems, we see that the small farms in stratum 1 have the steepest slope, while the large farms in stratum 4 have the gentlest slope – implying the greatest elasticity of acreage response to payments.

2.7 Summary and Conclusion

Besides private market goods, agriculture jointly produces a number of public goods that are provided as externalities. This paper examines the incentives of farmers to participate in hypothetical programs to promote cropping systems that would increase production of these nonmarket ecosystem services. Based on a survey of Michigan corn and soybean farmers, we examine stated willingness to adopt sets of cropping practices that embody increasing levels of environmental stewardship. Farmer willingness to adopt these practices is a function of the payment offered, the farmer's perception of environmental improvements from the new cropping system, and total land acreage operated. The amount of acreage farmers would be willing to enroll depends consistently on farm size and the perception of environmental improvements from the practices. Among farms over 500 acres, the payment offered was also a significant inducement to enrolling acreage in these environmentally beneficial cropping programs. We find that under a payment for environmental service program, large farms are the low cost providers of the ecosystem services associated with the cropping systems we studied.

This paper advances the literature on adoption of agro-environmental practices by developing a supply function for crop acreage managed for environmental stewardship. Like prior studies of environmental technology adoption in agriculture, we find that environmental attitudes and affiliations, age, education and current farming practices are influential. But we find that the marginal contribution of environmental services –like most food– is likely to come from the largest farms. These are the ones that exhibit the greatest price elasticity of acreage supply. Notwithstanding the image of the small farmer as environmental steward, future agro-environmental policies that aim for cost-effective environmental impact will likely achieve most of their impact from larger farms.

Figure 2.1 Predicted Farm-level Supply Curves of Acreage Enrolled by Cropping System, 1688 Michigan Corn or Soybean Farms, 2008.

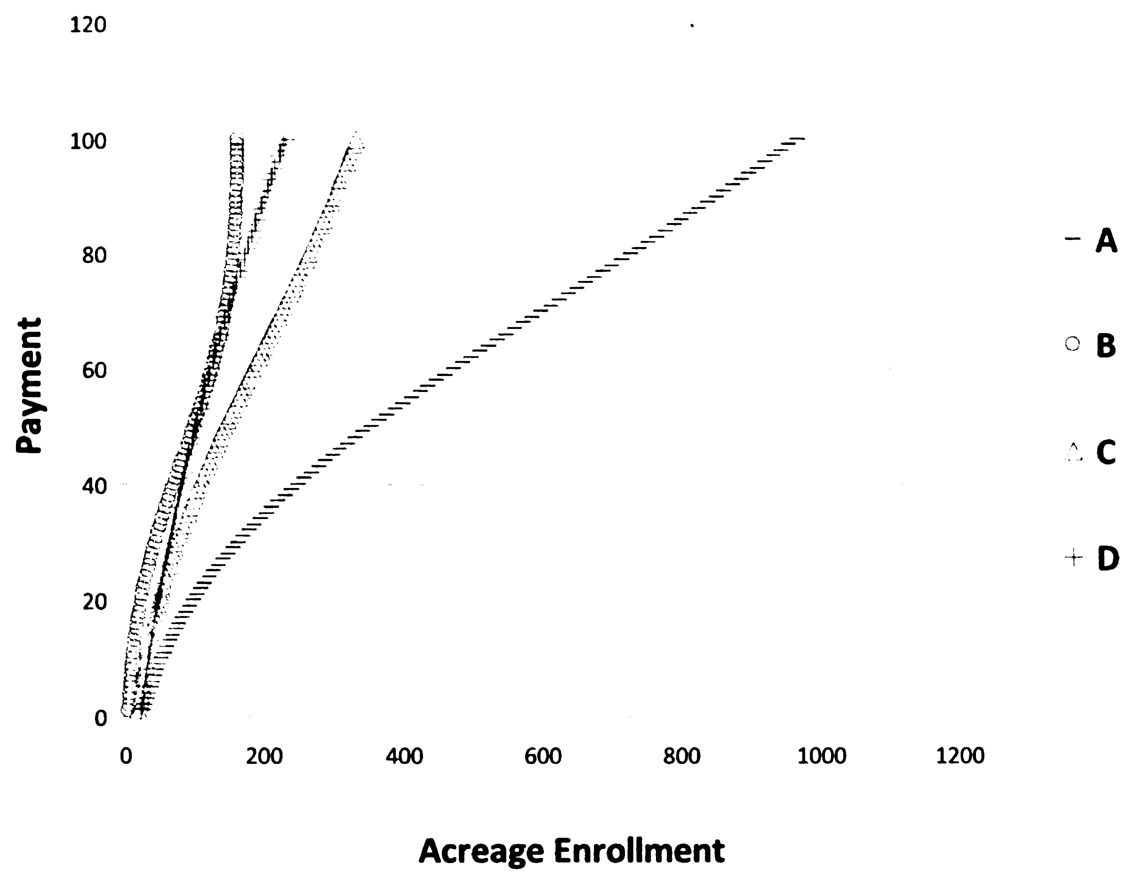

Figure 2.2 Predicted Farm-level Supply Curves of Acreage Enrolled by Farm Size Stratum and by Cropping System, 1688 Michigan Corn or Soybean Farms, 2008.

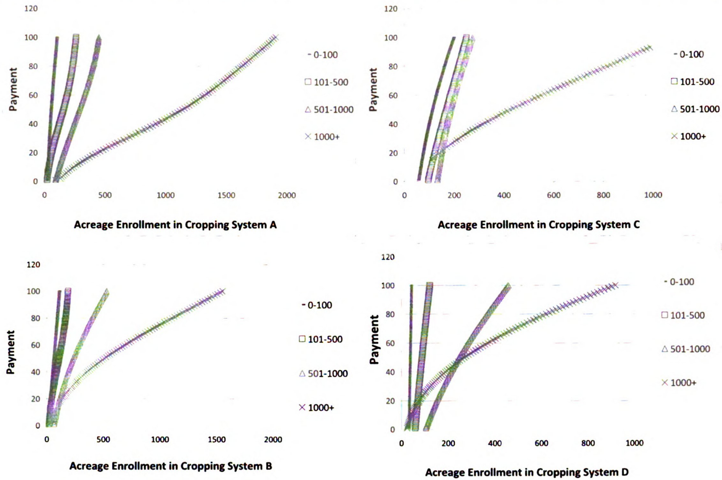

Table 2.1 Specific Practices of the Cropping Systems presented in the Questionnaire

	A	B	C	D
Rotation	Corn-Soybean	Corn-Soybean	Corn-Soybean-Wheat	Corn-Soybean-Wheat
Cover Crops	None	Any type present over winter	Any type present over winter	Any type present over winter
Tillage	Chisel plow with cultivation as needed	Chisel plow with cultivation as needed	Chisel plow with cultivation as needed	Chisel plow with cultivation as needed
Soil Test	Pre-sidedress Nitrate Test (PSNT)	Pre-sidedress Nitrate Test (PSNT)	Pre-sidedress Nitrate Test (PSNT)	Pre-sidedress Nitrate Test (PSNT)
Fertilization	Broadcast fertilizers at full MSU rates and split Nitrogen based on PSNT	Broadcast fertilizers at full MSU rates and split Nitrogen based on PSNT	Broadcast fertilizers at full MSU rates and split Nitrogen based on PSNT	Band apply over row at MSU rates and split Nitrogen based on PSNT
Pesticide Rate	Broadcast pesticides at a label rate	Broadcast pesticides at a label rate	Broadcast pesticides at a label rate	Band apply pesticides over row at a label amount

Source: Crop Management and Environmental Stewardship Survey

Table 2.2 Descriptive Statistics for the Variables used in Regression Analysis, weighted by farm size stratum,1688 Michigan corn or soybean farmers, 2008

Variable	Unit or Type	Mean Value	Standard Error
Version			
Government	Dummy	0.5284	(0.040)
Descending Sequence	Dummy	0.5361	(0.040)
Payment for Cropping System A	Dollars	10.13	(0.400)
Payment for Cropping System B	Dollars	24.12	(0.699)
Payment for Cropping System C	Dollars	35.34	(0.939)
Payment for Cropping System D	Dollars	48.93	(1.27)
Perceived Environmental Performance of Proposed Systems			
System A	Likert 1-5*	3.056	(0.066)
System B	Likert 1-5*	3.317	(0.061)
System C	Likert 1-5*	3.552	(0.059)
System D	Likert 1-5*	3.631	(0.057)
Biophysical Variables			
Sandy Soil	Dummy	0.3194	(0.038)
Silty Soil	Dummy	0.0394	(0.014)
Clay Soil	Dummy	0.5118	(0.040)

ContinuedTable 2.2 Descriptive Statistics for the Variables used in Regression Analysis, weighted by farm size stratum,1688 Michigan corn or soybean farmers, 2008

Variable	Unit or Type	Mean Value	Standard Error
Current Practices			
Moldboard tillage (Proportion of Land Managed)	Ratio	0.1637	(0.024)
No till tillage (Proportion of Land Managed)	Ratio	0.1292	(0.017)
Conservation tillage (Proportion of Land Managed)	Ratio	0.3516	(0.027)
Wheat (Proportion of Land Managed)	Ratio	0.0940	(0.010)
Cover Crops (Proportion of Land Managed)	Ratio	0.0721	(0.017)
Total Land Managed	Acres	453.301	(31.8)
Expected Prices			
Wheat to Corn price ratio	Ratio	1.725	(0.031)
Wheat to Soybean price ratio	Ratio	0.8044	(0.051)
Environmental Program Experience			
MAEAP	Dummy	0.1277	(0.027)
EQIP	Dummy	0.1440	(0.023)
CRP	Dummy	0.2120	(0.302)
CSP	Dummy	0.0667	(0.0154)
Demographics			
Age	Years	54.03	(1.02)
Education Years	Years	13.67	(0.189)

* Mean value constructed from six Likert scale variables for level of agreement that proposed cropping system would improve environmental performance compared to farmer's current system (1=strongly disagree; 5=strongly agree)

Table 2.3 Participation Decision in the Environmental Stewardship Practices (Probit Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Version				
Government	-0.1050	0.0082	0.0527	-0.0779
	(0.20)	*(0.18)*	*(0.20)*	*(0.19)*
Descending Sequence	-0.7069***	-0.3256*	-0.4307*	0.2279
	(0.19)	*(0.19)*	*(0.19)*	*(0.19)*
Payment offer for Proposed System	0.0269*	0.0442***	0.0279***	0.0069*
	(0.02)	*(0.01)*	*(0.01)*	*(0.01)*
Perceived Environmental Performance	0.6899***	0.3989***	0.6226***	0.6263***
	(0.14)	*(0.13)*	*(0.12)*	*(0.14)*
Biophysical Variables				
Sandy Soil	0.3071	-0.3529	0.0169	-0.2289
	(0.33)	*(0.33)*	*(0.33)*	*(0.32)*
Silty Soil	-0.3743	-0.3151	-0.3512	0.2744
	(0.43)	*(0.54)*	*(0.45)*	*(0.48)*
Clay Soil	0.2841	-0.2927	-0.0207	-0.4243
	(0.32)	*(0.31)*	*(0.29)*	*(0.31)*

Continued Table 2.3 Participation Decision in the Environmental Stewardship Practices (Probit Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Current Practices				
Moldboard tillage	-1.0333*	-2.7176***	-1.3516**	-1.0901**
	(0.71)	*(0.75)*	*(0.55)*	*(0.46)*
No till tillage	0.1983	0.8308*	0.4138	0.5059
	(0.51)	*(0.49)*	*(0.52)*	*(0.46)*
Conservation tillage	0.3157	0.4617	-0.0808	0.3436
	(0.39)	*(0.36)*	*(0.35)*	*(0.35)*
Wheat Ratio	-2.0089**	0.7766	1.3810*	0.0775
	(0.96)	*(0.87)*	*(0.81)*	*(0.84)*
Cover Crops Ratio	-0.4831	0.0772*	0.0639	0.0274
	(0.76)	*(0.06)*	*(0.66)*	*(0.49)*
Total Land Managed	0.0002***	0.0001*	0.0001*	0.0001*
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*
Expected Prices				
Wheat price to corn price ratio	1.2601***	0.4510	-0.2531	0.0893
	(0.44)	*(0.31)*	*(0.26)*	*(0.28)*
Wheat price to soy price ratio	-1.2469	0.1602**	0.2171*	0.2421
	(0.85)	*(0.16)*	*(0.13)*	*(0.12)*

Continued Table 2.3 Participation Decision in the Environmental Stewardship Practices (Probit Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Environmental Program Experience				
MAEAP	0.0464	-0.7526	-0.0995	-0.3121
	(0.27)	*(0.25)*	*(0.31)*	*(0.23)*
EQIP	0.5735**	0.4071*	0.7149***	0.9189***
	(0.25)	*(0.21)*	*(0.26)*	*(0.23)*
CRP	0.4579	-0.0978	0.0298	0.1022
	(0.23)	*(0.23)*	*(0.21)*	*(0.22)*
CSP	-0.1695	-0.1966	-0.3629	-0.8617
	(0.30)	*(0.27)*	*(0.31)*	*(0.28)*
Demographics				
Age	-0.0113*	-0.0128*	-0.0108*	-0.0119
	(0.01)	*(0.01)*	*(0.01)*	*(0.01)*
Education Years	0.0410	0.0612	0.0318	0.0328
	(0.05)	*(0.05)*	*(0.04)*	*(0.04)*
Intercept	-5.8257***	-4.4528***	-3.6325***	-3.4891
	(1.19)	*(1.14)*	*(1.21)*	*(1.17)*
N =	642	639	647	656
Log likelihood values	-239.471	-254.851	-321.773	-361.357
Wald chi squared	109.33	110.66	97.95	82.25
Probability chi squared	0.0000	0.0000	0.0000	0.0000
Pseudo R squared	0.2558	0.2544	0.2403	0.1883

Numbers in the parentheses are reported standard errors.

***-significant at 1% level, **-significant at 5% level, *-significant at 10% level

Table 2.4 Acreage Decision in the Environmental Stewardship Practices (Truncated Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Version				
Government	-68.736*	25.022	-13.566	-57.918**
	(38.66)	*(28.07)*	*(25.82)*	*(28.15)*
Descending Sequence	-21.505	-10.489	-34.62	-32.566
	(44.21)	*(27.37)*	*(29.34)*	*(24.38)*
Payment offer for Proposed System	8.5125**	0.1986	1.8316*	3.6052***
	(3.93)	*(1.54)*	*(1.05)*	*(0.91)*
Perceived Environmental Performance	25.803*	19.364*	5.8653*	6.3097*
	(20.31)	*(17.83)*	*(1.78)*	*(2.17)*
Biophysical Variables				
Sandy Soil	-86.157	7.6822*	53.653*	57.063
	(57.39)	*(3.99)*	*(44.62)*	*(60.81)*
Silty Soil	45.092	87.557*	4.5427	36.987
	(167.71)	*(82.45)*	*(68.27)*	*(78.09)*
Clay Soil	48.987*	57.603*	95.520*	94.271*
	(48.94)	*(33.28)*	*(44.54)*	*(57.93)*

Continued Table 2.4 Acreage Decision in the Environmental Stewardship Practices (Truncated Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Current Practices				
Moldboard tillage	-363.63***	-96.744	-96.990*	-75.239*
	(99.85)	*(226.19)*	*(93.60)*	*(69.22)*
No till tillage	-211.01**	-33.193	-23.710	-25.577
	(88.32)	*(72.10)*	*(73.25)*	*(74.71)*
Conservation tillage	-171.32**	2.0510	-66.877	-70.619
	(83.21)	*(65.35)*	*(63.79)*	*(51.97)*
Wheat Ratio	-0.4476	-100.12	119.68*	293.76**
	(128.69)	*(109.64)*	*(103.30)*	*(114.99)*
Cover Crops Ratio	-33.375	-12.094	3.7043	73.600
	(103.38)	*(115.89)*	*(79.08)*	*(61.54)*
Total Land Managed	0.1987***	0.1587***	0.2458***	0.3131***
	(0.03)	*(0.02)*	*(0.03)*	*(0.04)*
Expected Prices				
Wheat price to corn price ratio	-200.99**	-192.04***	-8.7528	50.985*
	(81.54)	*(60.55)*	*(44.44)*	*(33.64)*
Wheat price to soy price ratio	262.17*	383.29***	21.306*	125.46*
	(165.74)	*(133.55)*	*(18.48)*	*(19.44)*

Continued Table 2.4 Acreage Decision in the Environmental Stewardship Practices (Truncated Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Environmental Program Experience				
MAEAP	-156.93**	-134.82	17.242	-68.573
	(62.58)	*(61.08)*	*(46.85)*	*(59.89)*
EQIP	-91.281	10.498	-55.056	8.804
	(61.61)	*(50.68)*	*(44.65)*	*(50.77)*
CRP	-6.9688	38.709	47.623	57.407*
	(41.57)	*(34.73)*	*(36.05)*	*(32.68)*
CSP	94.097	28.544	63.562	38.494
	(68.74)	*(61.74)*	*(64.50)*	*(74.12)*
Demographics				
Age	-4.0063***	-2.2109	-1.9273*	0.6648
	(1.53)	*(1.50)*	*(1.13)*	*(1.36)*
Education Years	6.9434	0.9451	3.6366	9.5676**
	(6.34)	*(6.01)*	*(2.60)*	*(4.58)*
Intercept	604.42***	197.48*	272.05	-13.809
	(226.23)	*(154.42)*	*(184.42)*	*(191.56)*
N=	165	206	285	291
Log pseudolikelihood values	-756.249	-814.661	-1364.405	-1577.31
Wald chi squared	187.15	132.12	158.26	181.43
Probability chi squared	0.0000	0.0000	0.0000	0.0000

Numbers in the parentheses are reported standard errors.

***-significant at 1% level, **-significant at 5% level, *-significant at 10% level

Table 2.5 Participation Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Version				
Government	-0.1396	-0.1251	-0.0976	-0.1285
	(0.19)	*(0.18)*	*(0.18)*	*(0.17)*
Descending Sequence	-0.6057***	-0.2221	-0.4080**	-0.1479
	(0.18)	*(0.18)*	*(0.17)*	*(0.17)*
Payment*Stratum1	-0.0384	0.0042	0.0123	0.0150*
	(0.05)	(0.02)	(0.01)	(0.01)
Payment*Stratum2	-0.0260	0.0197	0.0220**	0.0138**
	(0.02)	(0.01)	(0.01)	(0.01)
Payment*Stratum3	0.0425*	0.0192*	0.0216***	0.0159***
	(0.02)	(0.01)	(0.01)	(0.01)
Payment*Stratum4	0.0650***	0.0153**	0.0244***	0.0245***
	(0.02)	*(0.01)*	*(0.01)*	(0.01)
Perceived Environmental Performance	0.7060***	0.5923***	0.6038***	0.5391***
	(0.13)	*(0.11)*	*(0.11)*	*(0.11)*
Biophysical Variables				
Sandy Soil	-0.3948	-0.0195	0.2406	0.8242***
	(0.31)	*(0.29)*	*(0.32)*	*(0.30)*
Silty Soil	-1.0034	1.0907***	-0.1112	0.0171
	(0.64))	*(0.42)*	*(0.51)*	*(0.45)*
Clay Soil	-0.1730	0.1731	0.2026	0.8232***
	(0.28)	*(0.27)*	*(0.29)*	*(0.27)*

Continued Table 2.5 Participation Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Current Practices				
Moldboard tillage	-1.7883**	-2.8744***	-1.1712	-1.4516**
	(0.85)	*(0.86)*	*(0.74)*	*(0.68)*
No till tillage	-0.7303	-0.2242	-0.0091	0.1390
	(0.48)	*(0.46)*	*(0.47)*	*(0.44)*
Conservation tillage	0.5816	0.0796	0.4370	-0.2311
	(0.48)	*(0.43)*	*(0.37)*	*(0.39)*
Wheat Ratio	-0.0008	0.9967	2.9043***	2.3082***
	(1.10)	*(0.92)*	*(0.90)*	*(0.88)*
Cover Crops Ratio	-0.3791	0.4427*	-0.7560	-0.6135
	(0.64)	*(0.60)*	*(0.54)*	*(0.51)*
Total Land Managed	0.0001*	0.0001**	0.0001*	0.0002*
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*
Expected Prices				
Wheat price to corn price ratio	0.8253***	0.0705	0.0211	-0.1956
	(0.28)	*(0.30)*	*(0.27)*	*(0.25)*
Wheat price to soy price ratio	-0.0409	-0.3172	-0.2775	-0.0938
	(0.23)	*(0.32)*	*(0.22)*	*(0.18)*

Continued Table 2.5 Participation Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Environmental Program Experience				
MAEAP	-0.0103	-0.3566	-0.2714	0.3167
	(0.27)	*(0.28)*	*(0.26)*	(0.25)
EQIP	0.1049	0.3899*	0.0478	0.1906
	(0.23)	*(0.22)*	*(0.21)*	*(0.21)*
CRP	-0.3098	-0.1441	-0.0930	-0.0765
	(0.21)	*(0.20)*	*(0.20)*	*(0.19)*
CSP	0.3172	-0.0119	0.3270	-0.0660
	(0.31)	*(0.29)*	*(0.31)*	*(0.28)*
Demographics				
Age	-0.0015	-0.0017	-0.0058	-0.0069
	(0.01)	(0.01)	*(0.01)*	*(0.01)*
Education Years	0.0065	0.0086	0.0544	0.0074
	(0.04)	*(0.04)*	*(0.04)*	*(0.04)*
Intercept	-3.9517***	-2.4900**	-3.6200***	-2.7357***
	(1.15)	*(1.07)*	*(1.08)*	*(1.05)*
N =	647	644	652	661
Log likelihood values	-275.338	-339.640	-357.990	-376.662
Wald chi squared	88.41	69.02	84.11	73.27
Probability chi squared	0.000	0.0000	0.0000	0.0000
Pseudo R squared	0.2436	0.1586	0.1999	0.1743

Numbers in the parentheses are reported standard errors.

***-significant at 1% level, **-significant at 5% level, *-significant at 10% level

Table 2.6 Acreage Decision in the Environmental Stewardship Practices with Payment Effects,by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Version				
Government	-210.4295***	-142.2582***	-131.9641**	-108.1522
	(63.09)	*(50.94)*	*(59.14)*	*(66.75)*
Descending Sequence	-267.6296***	-56.8632	-127.7693**	-91.4838
	(63.54)	*(46.79)*	*(52.55)*	*(56.61)*
Payment*Stratum1	-20.3747**	-8.0509*	-0.6727	0.8724
	(10.33)	(4.33)	(2.42)	(3.02)
Payment*Stratum2	-1.6118	-3.0010	-3.1269	2.0692
	(9.54)	(4.01)	(1.92)	(2.47)
Payment*Stratum3	17.7353***	7.0930*	4.9151**	5.2741**
	(6.40)	(3.70)	(2.33)	(2.35)
Payment*Stratum4	32.3271***	9.1168**	4.5525**	9.4482***
	(8.72)	*(4.53)*	*(1.98)*	*(2.44)*
Perceived Environmental Performance	89.8040**	64.2607*	68.2148**	28.6643*
	(58.48)	*(38.37)*	*(44.27)*	*(57.06)*
Biophysical Variables				
Sandy Soil	-35.7487	264.1814***	139.7238*	132.8064
	(147.61)	*(76.95)*	*(82.97)*	*(128.35)*
Silty Soil	-259.1915	194.5706	-36.5880	-52.3980
	(176.17)	*(129.62)*	*(122.50)*	*(148.27)*
Clay Soil	215.7592*	265.8358***	262.7868***	147.8422*
	(129.71)	*(79.34)*	*(78.46)*	*(122.36)*

Continued Table 2.6 Acreage Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Current Practices				
Moldboard tillage	-1223.069***	193.9493	-700.046**	-510.3832
	(348.22)	(527.24)	*(291.33)*	*(343.30)*
No till tillage	-420.8124*	-66.7417	-17.1656	98.5053
	(234.77)	*(186.28)*	*(184.58)*	*(202.38)*
Conservation tillage	-165.1821	49.8453	-89.8856	203.0138*
	(170.19)	*(139.63)*	*(118.90)*	*(113.77)*
Wheat Ratio	-88.4261	35.4787	424.584	515.3281
	(370.66)	*(204.75)*	*(261.70)*	*(326.37)*
Cover Crops Ratio	247.8761	166.8248*	251.5119	314.5113*
	(291.18)	*(120.00)*	*(217.61)*	*(179.68)*
Total Land	0.0484*	0.0798***	0.0767**	0.1684***
	(0.03)	*(0.02)*	*(0.03)*	*(0.06)*
Expected Prices				
Wheat price to corn price ratio	-153.9982	-167.5354***	148.3817**	347.0651***
	(100.64)	*(48.48)*	*(65.63)*	*(94.90)*
Wheat price to soy price ratio	316.262***	597.7731***	376.9607***	444.9625***
	(94.45)	*(45.63)*	*(115.73)*	*(116.76)*

Continued Table 2.6 Acreage Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Environmental Program Experience				
MAEAP	-459.8402***	105.0515	-24.6032	-118.7978
	(130.24)	*(106.39)*	*(67.78)*	*(94.72)*
EQIP	190.9967	-38.8960	-27.5810	73.9469
	(125.29)	*(74.59)*	*(75.10)*	*(92.87)*
CRP	102.8771	34.4273	22.1721	99.4717
	(94.09)	*(67.67)*	*(87.51)*	*(73.68)*
CSP	-174.2692	49.2300	164.5491	-81.2954
	(136.41)	*(75.75)*	*(142.81)*	*(123.41)*
Demographics				
Age	-6.1475**	0.4137	-4.8317**	5.1873
	(2.76)	*(2.91)*	(2.05)	*(3.32)*
Education Years	21.0005*	11.1757	-10.7225	-12.1584
	(11.61)	*(8.68)*	*(12.63)*	*(11.93)*
Intercept	289.74	-679.7855**	163.1455	-180.4859
	(378.46)	*(329.56)*	*(323.11)*	*(399.08)*
N =	168	207	286	292
Log pseudolikelihood values	-1816.731	-2207.975	-3205.686	-3549.953
Wald chi squared	694.31	999.34	307.84	206.38
Probability chi squared	0.0000	0.0000	0.0000	0.0000

Numbers in the parentheses are reported standard errors.

***-significant at 1% level, **-significant at 5% level, *-significant at 10% level

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Conclusion

Agriculture is a managed ecosystem. The decisions of its managers, the farmers, drive the mix of ecosystem services (ES) that it produces. Essay 1 developed tradeoff analysis between profitability and selected environmental indicators for different types of cropping systems from research field trials. The tradeoff frontiers developed in the study are profit vis-à-vis global warming potential (GWP) and nitrate leaching. Both revealed that the conventional treatment is dominated. The organic treatment was dominated unless subject to certified organic prices. The no-till cropping system showed potential as an efficient choice for the farmer. With the method presented in this study, it was shown that tradeoffs exist as farmers make choices between environmental and economic goals. These tradeoffs imply that there are costs involved in changing cropping systems and many farmers would need to be compensated to adopt these practices. Trade-off curves represent a convenient means of summarizing the information for policy makers and form the basis for conceptualizing sustainability policies.

Essay 2 used survey data to examine farmers' willingness to enroll in a program that compensates them for adopting environmental stewardship. Based on a survey of 1,688 Michigan corn and soybean farmers, stated willingness to adopt sets of cropping practices that embody increasing levels of environmental stewardship was examined. Farmer willingness to adopt these practices was found to be a function of the payment offered, the farmer's perception of environmental improvements from the new cropping system, and total land acreage operated. The results showed that Michigan farmers' willingness to enroll acreage in an environmental stewardship program depends chiefly on farm size and the perception of environmental improvements from the practices. For farms over 500 acres, the payment offered was also a significant inducement to acreage enrollment in all systems examined.

The second essay also developed a supply function for crop acreage managed for environmental stewardship, using the participation and acreage enrollment equations estimated. It was found that the low cost suppliers of environmental services are the largest farms as exhibited by their greater price elasticity of acreage supply. Notwithstanding the image of the small farmer as environmental steward, future agro-environmental policies that aim to have the most cost-effective environmental impact will likely achieve most of their impact from larger farms.

APPENDIX ONE: Enterprise Budgets For the Cropping Systems Used in Essay 1

Appendix Table 1. Enterprise Budget for Treatment 1, Conventional System, KBS-LTER, Hickory Corners, Michigan, 1993-2007

Revenue Sources	**Unit**	**Corn**	**Soybean**	**Wheat**	**Average***
Yield	bu/acre	86.2	34.7	52.6	
Price	$/bu	2.66	6.09	3.29	
Revenue	$/acre	229	211	173	**204.68**
Cash Expenses					
Seed	$/acre	36.6	28.5	19.6	
Fertilizer	$/acre	20.5	12.4	7.89	
Herbicides	$/acre	18.8	21.6	20.8	
Tillage Costs	$/acre	11.5	11.9	12.7	
Custom Costs (Planting and Harvesting)	$/acre	12.1	6.73	7.39	
Cash Expenses	$/acre	99.6	81.2	68.5	**83.16**
Revenue Above Selected Cash Expenses		129.72	129.95	104.89	**121.52**

* Average was taken to assume a balanced rotation where a third of available land is planted to each crop in each year.

Appendix Table 2. Enterprise Budget for Treatment 2, No Till Cropping System, KBS-LTER, Hickory Corners, Michigan, 1993-2007

Revenue Sources	Unit	Corn	Soybean	Wheat	Average*
Yield	bu/acre	92.0	39.4	54.4	
Price	$/bu	2.66	6.09	3.29	
Revenue	$/acre	244	239	179	**221.42**
Cash Expenses					
Seed	$/acre	37.2	29.4	18.2	
Fertilizer	$/acre	18.1	10.1	5.07	
Herbicides	$/acre	30.4	35.3	34.7	
Tillage Costs	$/acre	0	0	0	
Custom Costs (Planting and Harvesting)	$/acre	12.2	6.73	7.39	
Cash Expenses	$/acre	97.9	81.6	65.4	**81.63**
Revenue Above Selected Cash Expenses		147.09	158.35	113.19	**139.79**

* Average was taken to assume a balanced rotation where a third of available land is planted to each crop in each year.

Appendix Table 3. Enterprise Budget for Treatment 3, Low Input Cropping System, KBS-LTER, Hickory Corners, Michigan, 1993-2007

Revenue Sources	**Unit**	**Corn**	**Soybean**	**Wheat**	**Average***
Yield	bu/acre	88.4	36.2	46.0	
Price	$/bu	2.66	6.09	3.29	
Revenue	$/acre	235	220	151	**202.33**
Cash Expenses					
Seed	$/acre	37.2	26.7	19.7	
Cover Crop	$/acre	5.88	5.88	5.88	
Fertilizer	$/acre	11.7	2.98	3.93	
Herbicides	$/acre	6.86	7.02	5.35	
Tillage Costs	$/acre	10.9	10.4	11.2	
Custom Costs (Planting and Harvesting)	$/acre	12.2	6.73	13.9	
Cash Expenses	$/acre	84.7	59.7	60.0	**68.14**
Revenue Above Selected Cash Expenses		150.58	160.56	91.41	**134.19**

* Average was taken to assume a balanced rotation where a third of available land is planted to each crop in each year.

Appendix Table 4. Enterprise Budget for Treatment 4, Organic System (Non-Organic Prices), KBS-LTER, Hickory Corners, Michigan, 1993-2007

Revenue Sources	**Unit**	**Corn**	**Soybean**	**Wheat**	**Average***
Yield	bu/acre	65.0	34.9	30.6	
Price	$/bu	2.66	6.09	3.30	
Revenue	$/acre	173	212	100	**161.96**
Cash Expenses					
Seed	$/acre	52.2	32.0	45.0	
Cover Crop	$/acre	4.77	4.77	4.77	
Fertilizer	$/acre	0	0	0	
Herbicides	$/acre	0	0	0	
Tillage Costs	$/acre	18.6	20.7	20.5	
Custom Costs (Planting and Harvesting)	$/acre	12.2	6.73	13.9	
Cash Expenses	$/acre	87.8	64.2	84.2	**78.72**
Revenue Above Selected Cash Expenses		85.32	147.97	16.42	**83.24**

* Average was taken to assume a balanced rotation where a third of available land is planted to each crop in each year.

Appendix Table 5. Enterprise Budget for Treatment 4, Organic System (Organic prices), KBS-LTER, Hickory Corners, Michigan, 1993-2007

Revenue Sources	**Unit**	**Corn**	**Soybean**	**Wheat**	**Average***
Yield	bu/acre	65.0	34.9	30.6	
Price	$/bu	3.01	12.3	5.49	
Revenue	$/acre	195	428	167	**263.98**
Cash Expenses					
Seed	$/acre	52.2	32.0	45.0	
Cover Crop	$/acre	4.77	4.77	4.77	
Fertilizer	$/acre	0	0	0	
Herbicides	$/acre	0	0	0	
Tillage Costs	$/acre	18.6	20.1	20.6	
Custom Costs (Planting and Harvesting)	$/acre	12.2	6.73	13.9	
Cost of certification procedures and costs	$/acre	3.14	3.14	3.14	
Cash Expenses	$/acre	91.0	67.3	87.3	**81.87**
Revenue Above Selected Cash Expenses		104.81	361.14	80.40	**182.12**

* Average was taken to assume a balanced rotation where a third of available land is planted to each crop in each year.

Appendix Table 6. Enterprise Budget for Perennial Crop Poplar based on a single ten-year cycle, adjusted to reflect Net Present Value

	Quantity	Unit	Price per Unit ($)	1989	1990	1991	1992	1993	1994	1995
				1	2	3	4	5	6	7
Revenue Sources										
Wood yield	2.60	ton	45.00	0	0	0	0	0	0	0
Total Revenue				0	0	0	0	0	0	0
Cash Expenses										
Planting										
Cutting	1100.00	cutting	0.20	220.00	0	0	0	0	0	0
Oats	3.00	Bu	8.19	25.00	25.00	0	0	0	0	0
Fertilizers										
Nitrogen	109.73	lbs/acre	0.71	77.91	0	0	0	0	0	0
Pest Control										
Lorox	55.84	gal/acre	133.67	55.84	0	0	0	0	0	0
Princep	6.93	gal/acre	16.60	6.93	0	0	0	0	0	0
Roundup	12.71	gal/acre	33.80	0	0	0	0	0	0	0
Custom Costs										
Disking	1 acre		7.55	7.55	0	0	0	0	0	0
Plowing	1 acre		3.54	3.54	0	0	0	0	0	0
Harvest										
Cutting/Hauling	2.60	ton	18.00	0	0	0	0	0	0	0
Total Cash Expenses										
Revenue Above Selected Cash Expenses										

Note: This analysis uses a single ten-year cycle, and average ton/year is based on annual average of total growth over ten years in previous studis on short rotation poplar (Miller, 2008; Miller, 2002; Dickmann, 2001). Profit from Poplar is a one-off event at year 10, and this is reflected in the annualized present value of the profitability of the system.

Source: Application rates from KBS-LTER project; prices are at current prices (see input prices and out prices table sources)

* annuity is computed at present value of an annuity of t years (PVA) at an interest rate r=5% and time-t, divided by the present value interest factor for an annuity (PVIFA) whose value was taken from table A.4 Appendix A of Weston and Copeland, Managerial Finance, 1986 at PVIFA for a 10 year 5% interest rate

Continued Appendix Table 6. Enterprise Budget for Perennial Crop Poplar based on a single ten-year cycle, adjusted to reflect Net Present Value

	Quantity	Unit	Price per Unit ($)	1996	1997	1998	Total	Present Value (at 5% interest rate)	Annualized*
				8	9	10			
Revenue Sources									
Wood yield	2.60	ton	45.00	0	0	26.00			
Total Revenue				0	0	1170.00	1170.00	**718.30**	**93.02**
Cash Expenses									
Planting									
Cutting	1100.00	cutting	0.20	0	0	0	220.00	209.52	27.13
Oats	3.00	Bu	8.19	0	0	0	49.00	46.49	6.02
Fertilizers									
Nitrogen	109.73	lbs/acre	0.71	0	0	0	78.62	74.20	9.61
Pest Control									
Lorox	55.84	gal/acre	133.67	0	0	0	55.84	53.18	6.89
Princep	6.93	gal/acre	16.60	0	0	0	6.93	6.60	0.86
Roundup	12.71	gal/acre	33.80	0	12.71	0.00	12.71	8.19	1.06
Custom Costs									
Disking	1 acre		7.55	0	0	0	7.55	7.19	0.93
Plowing	1 acre		3.54	0	0	0	3.54	3.37	0.44
Harvest									
Cutting/Hauling	2.60	ton	18.00	0	0	46.89	46.89	28.79	3.73
Total Cash Expenses								**437.54**	**56.66**
Revenue Above Selected Cash Expenses								**280.76**	**36.36**

Note: This analysis uses a single ten-year cycle, and average ton/year is based on annual average of total growth over ten years in previous studis on short rotation poplar (Miller, 2008; Miller, 2002; Dickmann, 2001). Profit from Poplar is a one-off event at year 10, and this is reflected in the annualized present value of the profitability of the system.

Source: Application rates from KBS-LTER project; prices are at current prices (see input prices and out prices table sources)

* annuity is computed at present value of an annuity of t years (PVA) at an interest rate r=5% and time-t, divided by the present value interest factor for an annuity (PVIFA) whose value was taken from table A.4 Appendix A of Weston and Copeland, Managerial Finance, 1986 at PVIFA for a 10 year 5% interest rate

Appendix Table 7. Enterprise Budget for Perennial Crop Alfalfa based on a 3 five-year cycle, adjusted to reflect Net Present Value (at current prices)

	1989	1990	1991	1992	1993	1994	1995	1996	1997
	1	2	3	4	5	1	2	3	4
Revenue Sources									
Alfalfa Haylage	0	6.60	5.84	4.56	3.25	1.65	5.39	3.05	4.30
Total Revenue	0	257.34	227.65	177.79	126.61	64.26	210.26	118.93	167.61
Cash Expenses									
Planting									
Seed	52.19	0	0	0	0	80.30	0	0	0
Fertilizers									
K20	0	0	34.70	9.92	19.33	13.39	6.77	24.79	29.75
0-46-0	0	0	21.60	0	0	0	0	21.60	0
boron	0	0	0	0	0	0	0	4.76	4.25
lime	0	0	0	0	0	0	3.08	3.08	3.08
Pest Control									
Ambush	0	0	21.95	0	0	0	0	0	0
Sevin	0	1.20	0	0	0	0	0	12.40	0
Concentrate	0	0	0	0	0	3.06	0	0	0
Dimate	0	0	0	0	0	1.90	0	3.70	0
Poast Plus	0	0	15.06	0	0	15.06	0	0	17.60
2, 4-D	0	0	0	0	3.32	0	0	0	0
Roundup	0	0	0	0	17.43	0	0	0	0
Field Operations									
Plowing	13.70	0	0	0	0	0	0	0	0
Cultivating	20.50	0	0	0	0	20.50	0	0	0
Disking	13.90	0	0	0	0	0	0	0	0
Raking	5.65	16.95	22.60	5.65	11.30	11.30	0	0	0
Harvest									
Cutting Hay	0	0	0	0	20.50	0	0	0	0
Baling	1.00	1.50	2.00	0.50	0.50	1.00	1.00	0.50	0
Chopping Silage	0	0	0	0	107.70	35.90	71.80	71.80	71.80
Flail Mowing	0	10.70	0	0	0	0	10.70	0	10.70
Haybine	18.40	36.80	36.80	36.80	27.60	18.40	9.20	27.60	0
Total Cash Expenses									
Revenue Above Selected Cash Expenses									

Source: Application rates from KBS-LTER project; prices are at current prices (see input prices and out prices table sources)

* annuity is computed at present value of an annuity of t years (PVA) at an interest rate r=5% and time-t, divided by the present value interest factor for an annuity (PVIFA) whose value was taken from table A.4 Appendix A of Weston and Copeland, Managerial Finance, 1986 at PVIFA for a 17 year 5% interest rate

Continued Appendix Table 7. Enterprise Budget for Perennial Crop Alfalfa based on a 3 five-year cycle, adjusted to reflect Net Present Value (at current prices)

	1998	1999	2000	2001	2002	2003	2004	Total	Present Value (at 5% interest rate)	Annualized
	5	1	2	3	4	5	1			
Revenue Sources										
Alfalfa Haylage	3.84	0.85	0.13	0.08	5.36	4.79	4.59	58.36		
Total Revenue	149.81	33.16	4.90	2.99	208.93	186.98	178.94	2276.14	**1524.37**	**140.65**
Cash Expenses										
Planting										
Seed	0	40.59	0	0	0	0	52.20	225.28	161.00	15.50
Fertilizers										
K20	6.77	0	0	0	0	41.64	0	211.84	139.00	13.38
0-46-0	0	0	0	0	43.20	21.60	0	123.25	72.14	6.94
boron	0	0	0	0	0	7.87	0	24.83	13.00	1.25
lime	3.08	4.01	0	0	0	0	0	16.35	11.00	1.06
Pest Control										
Ambush	0	0	0	0	0	0	0	21.95	19.00	1.83
Sevin	0	0	0	0	0	0	0	13.60	9.48	0.91
Concentrate	0	0	0	3.68	0	0	0	6.74	4.24	0.41
Dimate	0	0	0	0	0	0	0	5.60	3.92	0.38
Poast Plus	0	0	0	13.21	0	0	13.21	74.14	48.65	4.68
2, 4-D	0	0	0	3.88	0	0	0	7.20	4.66	0.45
Roundup	0	12.55	0	8.16	0	0	0	38.14	25.32	2.44
Field Operations										
Plowing	0	0	0	0	0	0	0	13.70	13.05	1.26
Cultivating	0	0	10.25	0	0	0	0	51.25	40.53	3.90
Disking	0	13.90	0.0	0	0	0	0	27.80	21.37	2.06
Raking	0	0	0	0	5.65	16.95	0	101.70	75.68	7.29
Harvest										
Cutting Hay	10.25	10.25	0	20.50	10.25	0	0	82.00	48.87	4.70
Baling	0.50	0.50	0	0	0.50	1.00	0	11.00	8.00	0.77
Chopping Silage	0	71.80	0	0	71.80	35.90	0	574.40	368.00	35.43
Flail Mowing	0	0	0	10.70	32.10	32.10	0	117.70	66.20	6.37
Haybine	9.20	0	0	0	0	0	0	220.80	179.19	17.25
Total Cash Expenses									**1332**	**128.26**
Revenue Above Selected Cash Expenses									192.07	**18.49**

Source: Application rates from KBS-LTER project; prices are at current prices (see input prices and out prices table sources)

* annuity is computed at present value of an annuity of t years (PVA) at an interest rate r=5% and time-t, divided by the present value interest factor for an annuity (PVIFA) whose value was taken from table A.4 Appendix A of Weston and Copeland, Managerial Finance, 1986 at PVIFA for a 17 year 5% interest rate

Appendix Table 8. Crop Prices Standard Deviations and Mean computed from Prices (1978-2008; deflated to 2008)

Crop	Standard Deviation	Mean
Corn	0.74	2.66
Soybean	1.61	6.09
Wheat	0.9	3.30

APPENDIX TWO: Overview, Goals, Study Design, Collection Procedure and Data Management for the Crop Management and Environmental Stewardship Survey

OVERVIEW

The survey about Crop Management and Environmental Stewardship was conducted as a mail survey with funding from the National Science Foundation under Human and Social Dynamics Grant No. 0527587 and Long-term Ecological Research Grant No. 0423627. It looks into the incentives of producing and consuming ecosystem services from low-input cropping systems. Questionnaires were sent to a stratified random sample of 3,000 corn or soybean producers in Michigan.

Respondents answered about their current crop management practices, opinions about links between the agriculture and environment, views on the importance of different possible environmental benefits linked to agriculture and their willingness to adopt several farming practices. Mailing and data collection were conducted from February 8 to March 14, 2008. Questionnaires were completed by 1688 individuals. The net response rate was 56.36%.

GOALS

The main goal of the survey about the Crop Management and Environmental Stewardship was to look into farmers' willingness to accept payment for environmental services from agriculture. The results of the survey will be used to help understand farmers' views about the costs and benefits of adopting low-input cropping practices. This knowledge will potentially help to shape future policies and programs to benefit Michigan farmers.

STUDY DESIGN

The study of Crop Management and Environmental Stewardship was conducted as a mail survey by the Department of Agricultural Economics at Michigan State University. The highest standards of quality survey research were employed in conducting this project.

The administrative coordination of the project was provided by Professor Scott Swinton. The graduate research assistant, Christine B. Jolejole, and was responsible for questionnaire design, data collection, coding and editing, and writing the methodology part as part of her Masters thesis. She was also responsible for ensuring data accuracy and conversion of raw Excel data into a STATA system file format for analysis. Professor Frank Lupi also actively advised the survey activities in Essay 2.

DATA COLLECTION PROCEDURES

The procedures used by the project for this mail survey were based on Mail and Telephone Surveys, by Don A. Dillman (Dilman, 1999). Mailing and data collection for the survey about Crop Management and Environmental Stewardship were conducted from February 8 to August 15, 2008.

The first mailing was sent on February 8, 2008. This was a personally signed prenotice letter informing the farmer that they would receive the questionnaire in a week. Michigan State University (MSU) embossed paper and envelops were used. All mailings were sent first class postage.

The second mailing was on February 15, 2008 and included the following: (1) a cover letter that invited the farmer to participate in the survey and was a part of a very small sample in the state, printed on Michigan State University letterhead and signed by Dr. Scott Swinton as the head of the project, (2) a survey instrument, a sixteen page questionnaire; (3) a dollar bill as incentive; and (4) a business reply envelope.

The third mailing consisted of a reminder postcard that was sent out to the entire sample on February 22. The postcard thanked the individuals if they had already filled out the questionnaire, and asked them to take time to complete the survey if they had not already done so.

On March 14, a fourth mailing was sent to all individuals who had not yet returned their survey. This mailing was identical procedurally to the second mailing except that it did not include the dollar bill; it included a copy of the questionnaire, a reminder cover letter, and a business reply envelope.

After the fourth mailing, by May 15, the response rate was deemed sufficient so no further mailing was done.

DATA MANAGEMENT

Editing and coding included the completion of two major tasks. First all the surveys were checked for response clarity to eliminate dual responses when single-answer responses were sought, or to create a separate category for multiple responses. Second, the coders transcribed all responses to open-ended and "other specify" questions. Data entering involved the use of double data entry, and merging the files to detect out-of-range values.

Finally, merging the two files, checking for inconsistencies and editing were done by one individual who was familiar with the questionnaire and the purpose of the study. Unclear or ambiguous responses were directed to the same person for resolution. In addition, conducted quality control was conducted and coded/edited surveys were reviewed throughout this phase. Once a complete file of the questionnaire was constructed, it was examined systematically to remove data errors. In addition, the excel spreadsheet itself was examined manually to identify the cases with paradoxical and inappropriate responses.

APPENDIX THREE: Questionnaire Design

QUESTIONNAIRE DESIGN

The initial draft of the questionnaire was provided to Professor Scott Swinton in November 2007. A total of 23 pretests were done from January 9 to January 29, 2008 and changes were subsequently made to the survey. The first pre-test session was conducted with five undergraduate students and six graduate students with crop and soil science backgrounds. The second pre-test session was conducted with agricultural extension agents. And finally eight face to face pre-testing and interviews were conducted with eight farmers during the corn and soybean research pest management meeting in January 2008. Professors Scott Swinton and Frank Lupi approved the final questionnaire prior to start of data collection. The questionnaire was divided into six sections.

Section one asked about the farmers' current crop management practices. This includes the acreage of crops they planted in 2007, the cropping rotation, soil texture, types of tillage, use of cover crops, soil tests, pre-sidedress nitrate test (PSNT) and price expectations.

Section two asked about the farmers' opinion about links between agriculture and the environment. It consisted of Likert scale questions assessing respondents' opinions.

Section three looked at the farmers' views on the importance of different possible environmental benefits linked to agriculture. They were asked about the importance of this environmental benefit to them vis-à-vis importance to society.

Section four asked about farmers' adoption of individual farming practices. They were asked whether they are currently using them, previously tried and somehow abandoned or if they have never tried them before.

Section five included the cropping systems payment offer questions. Four cropping systems were described in terms of the crop rotation, cover crops, tillage, soil test, fertilization and pesticide application rate. Farmers were then asked about their views on the environmental effects of this cropping system if any. They were also asked to consider the payment and write the number of acres they would enroll in this program.

Finally, section six asked for the demographic questions. They were asked about their farming history and intentions (year they started farming, for how many years they plan to continue farming) and background information (zip code, year born, and highest level of education completed).

APPENDIX FOUR: Sampling Design

SAMPLING FRAME DESIGN

Questionnaires were sent to a stratified random sample of corn and soybean growers in Michigan. The sample was obtained from the 2007 agricultural census mailing list of National Agricultural Statistics Service (NASS) office in Michigan. NASS provided the project with a stratified random sample of 3,000 corn and soybean farmers in Michigan.

Table below provides strata and number of respondents within it.

Appendix Table 9. Sampling Frame Design

Strata	Acres	Number of Farmers	Number of Sampled Farmers within each Cluster
1	0-100	9849	301
2	101-500	5545	1050
3	501-1000	1361	770
4	1000+	879	879

The survey sampling frame provided by NASS was a proportional allocation based on acreage of soybean and/or corn. The sample size was chosen to allow for comparison across strata. Within each stratum, the sample was a systematic random sample of the population.

APPENDIX FIVE: Bid Design

BID DESIGN

There are several approaches in estimating the range of bids for use in surveys. The common approach is to compute for the average or the mean. Another is to use the 50^{th} percentile or the median from prior WTP estimates. Since the goal was to be able to derive four different prices for each cropping system, the 20^{th}, 40^{th}, 60^{th} and 80^{th} percentile of the distribution were computed from the data gathered from the farmer focus groups conducted during February and March 2007.

The percentiles were computed from the predicted participation rates at various payment levels for each of the four crop systems based on the forecasts of the participation probit models estimated from the focus group data (Lupi et al, 2007).

To ensure that the percentiles of bids to be used in the survey were realistic, we asked Kim Wieber, one of the program coordinators of Conservation Security Program (CSP) of Natural Resource Conservation Service (NRCS) to give a price estimate for our suggested cropping systems in the survey.

Appendix Table 10 provides the percentiles for the bid design.

Appendix Table 10 Payment Level to Achieve Participation

(Based on Probit Participation Models using Focus Group Data)

		Cropping System			
		A	B	C	D
Percentile	10	n/a	11	n/a	14
	20	n/a	17	10	31
	30	3	21	22	42
	40	6	25	32	52
	50	9	28	41	62
	60	12	32	50	71
	70	15	36	60	81
	80	18	40	72	93
	90	23	46	89	109

References:

Lupi, F., R. Shupp, S.M. Swinton and L. Vangjel. 2007. Farmers' Willingness to Accept Payments for Providing Environmental Services. Michigan State University, East Lansing, Michigan. Unpublished manuscript.

APPENDIX SIX: Experimental Design and Versions

EXPERIMENTAL DESIGN

The experimental design determined the combinations of the varying factors within the questionnaire. There were 6 variables. Sequence of cropping system difficulty, which correlated positively with payment level (2 levels: ascending or descending), payment vehicle (Federal government or a non-governmental organization) and four cropping systems each with 4 levels or prices. Using a factorial design, the experimental design was drawn from 2^2*4^4 full factorial.

A main effects orthogonal array from this factorial design is composed of 16 alternatives under conditions. One condition is that no individual survey has decreasing prices moving from system A to system D. That condition was imposed on the design to truncate bids to prevent this from occurring. The resulting design matrix is balanced in the two binary variables and has low correlation among the variables except for two pairs B,C and C,D which have modest correlation but below 0.5.

VERSIONS

The sample was selected with 16 replicates within each stratum. Each replicate was a sample of the population. Each of the 16 questionnaire versions was assigned to a replicate. The questionnaire varied and has sixteen different versions (versions A-P). Variations include the cropping systems payment levels in section five (for details, see bid design), the sequence in which the cropping systems were proposed, and the payment vehicle or the funding agency for the cropping systems payment. Appendix Table 11 provides range of identification numbers and the particular version mailed.

Appendix Table 11 Crop Management and Environmental Stewardship Survey Experimental Design, Michigan, Feb-March 2008

Version	Respondent Number	Descending Sequence	Non-Governmental Organization	Subsidy or Payment for Cropping System A	Subsidy or Payment for Cropping System B	Subsidy or Payment for Cropping System C	Subsidy or Payment for Cropping System D
A	001-190	0	0	4	10	15	20
B	191-380	1	0	4	18	27	51
C	381-570	1	1	4	26	39	75
D	571-757	0	1	4	36	55	55
E	758-944	1	1	8	10	27	36
F	945-1131	0	1	8	18	18	75
G	1132-1318	0	0	8	26	55	55
H	1319-1505	1	0	8	36	39	39
I	1506-1692	0	1	12	12	39	51
J	1693-1879	1	1	12	18	55	55
K	1880-2066	1	0	12	26	26	36
L	2067-2253	0	0	12	36	36	75
M	2254-2440	1	0	17	17	55	75
N	2441-2627	0	0	17	18	39	39
O	2628-2814	0	1	17	26	27	27
P	2815-3000	1	1	17	36	36	51

APPENDIX SEVEN: Pre Notice, Cover Letters, Reminder Postcards and the Questionnaire

MICHIGAN STATE
UNIVERSITY

February __, 2008

Dear Valued Producer,

In a few days you will receive a questionnaire in the mail about Crop Management and Environmental Stewardship Survey. When the questionnaire arrives, please fill it out and mail it back promptly. Michigan State University in collaboration with the National Science Foundation is conducting this survey and chose your address, not you personally, as part of a randomly selected sample from Michigan Agricultural Statistical Service (MASS) survey mailing list..

Your farm is one of a small number whose managers are being asked to express their opinions. Thus, it is very important that you reply so that the results give the clearest possible picture of how herbicide choices are made in Michigan.

Thank you in advance for your help.

If you have questions about the research I would be most happy to answer any question you might have. You can e-mail me at swintons@msu.edu or call me at 1-517-353-7218

Sincerely,

Scott M. Swinton
Professor

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MICHIGAN STATE
UNIVERSITY

February __, 2008

Dear Valued Producer,

We would like to ask about your views on cropping practices and the environment. So we ask for a few minutes of your time to complete the attached questionnaire. This study is being conducted by Michigan State University with support from the National Science Foundation in order to understand better farmers' views on the appeal of adopting various low-input cropping practices. The results of this research will be analyzed and written up for publications that range from farm newspapers to academic journals. There are no right answers, because everyone farms different ground and has different management strategies and marketing plans.

Your farm is one of a small number whose managers are being asked to express their opinions. It was drawn in a random sample of corn and soybean growers from the entire state. In order that the results will truly represent the thinking of Michigan farmers, it is important that each questionnaire be completed and returned. It is also important that we get the views of the decision makers of the farms. Thus, we request that the questionnaire be completed by the person who mains most decisions on cropping practices on your farm.

S
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You may be interested to know that we researchers sending you this questionnaire will not have access to your name and contact information. The Michigan Agricultural Statistical Service manages the survey mailing list. It does not permit the researchers to have a copy of the address labels or to link your identity to the identification number assigned to (so we will know if you have replied so we can stop sending you questionnaires) from (MASS) for mailing purposes only. So your name will never be placed on the questionnaire and we researchers at MSU will not have any access to it. Your individual views will be completely confidential, and your privacy will be protected to the maximum extent permitted by law. Also, your participation in the survey is voluntary. You may choose not participate at all, refuse to answer certain questions, or end the survey any time.

If you have any questions or concerns regarding your rights as a study participant, you may contact Peter Vasilenko, Ph.D., Director of Human Subject Protection Programs at Michigan State University by phone: (517) 355-2180, email: irb@msu.edu.

If you have questions about the research I would be most happy to answer any question you might have. You can e-mail me at swintons@msu.edu or call me at 1-517-353-7218.

Thank you for your assistance.

Sincerely,

Scott M. Swinton
Professor

MICHIGAN STATE
UNIVERSITY

Crop Management and Environmental Stewardship:

A SURVEY OF YOUR OPINIONS

This research aims to understand farmers' views on adopting various low-input cropping practices. There are no right or wrong answers because everyone farms different ground and has different management strategies and marketing plans.

Your opinions matter!

By completing this questionnaire you are helping to inform the design of future policies that better reflect the views and concerns of Michigan farmers.

CROP MANAGEMENT AND ENVIRONMENTAL STEWARDSHIP STUDY

SECTION A: Your current crop management practices

A1. In 2007, did you plant corn or soybean?

☐ No ⟹ *If you answered NO, you do not need to continue filling out this questionnaire. Please return it in the envelope provided. Thank you for your time.*

☐ Yes

A2. Are you the main decision maker for annual crop management on your farm?

☐ No ⟹ *If you answered NO, please direct the questionnaire to the person who makes cropping decisions on the farm.*

☐ Yes

A3. In 2007, what were the main crops you planted and how many acres of each did you plant?
(Please write the corresponding number of acres in the right column.)

CROPS in 2007	ACRES
Corn	______ ACRES
Soybeans	______ ACRES
Wheat	______ ACRES
Alfalfa	______ ACRES
Oats	______ ACRES
Other *(please specify)*:	
________	______ ACRES
________	______ ACRES
________	______ ACRES

A4. Over the last 3 years, what was the crop sequence on most of your corn and soybean fields?

- ☐ Continuous corn
- ☐ Continuous soybean
- ☐ Corn-soybean
- ☐ Corn-corn-soybean
- ☐ Corn-soybean-wheat
- ☐ Others *(please specify)*: ____________________________________

A5. How would you describe the most common soil texture on your farm?

- ☐ Sand
- ☐ Silt
- ☐ Loam
- ☐ Clay
- ☐ Clay-loam
- ☐ Silty-loam
- ☐ Sandy-loam
- ☐ Others *(please specify)*: ____________________________________

A6. Did you grow soybeans in 2007?

- ☐ No *(please go to A8)*
- ☐ Yes

A7. What kind(s) of primary tillage did you chiefly practice in fall and spring when going into 2007 soybeans? *(Please mark the acres of each type below. There may be more than one answer.)*

TILLAGE GOING INTO SOYBEANS in 2007	FALL 2006	SPRING 2007
Moldboard plow	____________ ACRES	____________ ACRES
No-till	____________ ACRES	____________ ACRES
Chisel plow	____________ ACRES	____________ ACRES
Disc	____________ ACRES	____________ ACRES
Strip, zone or row tillage	____________ ACRES	____________ ACRES
Other *(please specify)*:		
________________	____________ ACRE	____________ ACRE

A8. Did you grow corn in 2007?

☐ No *(please go to A10)*

☐ Yes

A9. What kind(s) of primary tillage did you chiefly practice in fall and spring when going into 2007 corn? *(Please mark the acres of each type below. There may be more than one answer.)*

TILLAGE GOING INTO CORN in 2007	FALL 2006	SPRING 2007
Moldboard plow	______ ACRES	______ ACRES
No-till	______ ACRES	______ ACRES
Chisel plow	______ ACRES	______ ACRES
Disc	______ ACRES	______ ACRES
Strip, zone or row tillage	______ ACRES	______ ACRES
Other *(please specify)*:		
________	______ ACRES	______ ACRES

A10. Did you plant a cover crop after corn, soybeans or wheat in 2007?

☐ No *(please go to A11)*

☐ Yes

A10a. If YES, please specify what main crop it followed and how many acres of cover crops you planted. *(If none, please mark zero acres planted.)*

Here are some examples of cover crops:
Legume Cover Crops: Clovers, Hairy Vetch, Field Peas, Annual Medic, Alfalfa and Soybean
Non-legume Cover Crops: Rye, Oats, Wheat, Forage Turnips, Oilseed Radish and Buckwheat

MAIN CROP	COVER CROP (S)	ACRES
Corn	________	______ ACRES
Soybeans	________	______ ACRES
Wheat	________	______ ACRES

A11. Did you have soil tests done on your corn, soybean or wheat land since the beginning of 2005?

☐ No

☐ Yes ⟹ If YES, how many acres of crop land did you soil test? _________ ACRES

A12. Did you do pre-sidedress nitrate testing (PSNT) in 2007?

☐ No

☐ Yes ⟹ If YES, on how many acres did you use the PSNT? _________ ACRES

A13. Did you practice organic farming in 2007? (*Check all that apply.*)

☐ No

☐ Yes, Certified, on _________ ACRES

☐ Yes, Not currently certified, on _________ ACRES

A14. Which of the following types of farm products accounted for more than 10% of your farm revenues in 2007? *(Please check all that apply).*

☐ Field crops (including grains, oilseeds, sugarbeets, silage and hay)

☐ Fruit, nut and vegetable crops (including potato)

☐ Flowers, ornamentals and live plants (nursery crops)

☐ Milk and dairy products

☐ Livestock and animal products other than dairy

☐ Other *(please specify):* ____

A15. If you were to grow corn, soybean and wheat this year, what prices would you expect to receive for your 2008 harvest? *(Please answer for all three crops.)*

CROP	**EXPECTED HARVEST PRICE RECEIVED**
Corn	_____________ $/BUSHEL
Soybeans	_____________ $/BUSHEL
Wheat	_____________ $/BUSHEL

SECTION B. Your opinions about links between agriculture and the environment

B1. Please check the boxes that best represent your agreement with the following statements.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Less tillage is good for soil conservation.	☐	☐	☐	☐	☐
Winter cover crops are good for soil conservation.	☐	☐	☐	☐	☐
Cover crops increase soil fertility.	☐	☐	☐	☐	☐
Incorporating manure and fertilizer into soil reduces phosphorus runoff into waterways compared with surface application.	☐	☐	☐	☐	☐
Environmental stewardship only makes sense on my farm if it also contributes to income.	☐	☐	☐	☐	☐
Less tillage on my farm reduces global warming by storing carbon in soil.	☐	☐	☐	☐	☐
Applying nitrogen fertilizer based on a pre-sidedress nitrate test (PSNT) generally reduces nitrate leaching into water supplies.	☐	☐	☐	☐	☐
Applying nitrogen fertilizer based on a pre-sidedress nitrate test (PSNT) generally reduces global warming by reducing greenhouse gas emissions linked to nitrogen.	☐	☐	☐	☐	☐
Nature provides services that improve my crop production.	☐	☐	☐	☐	☐
By their choice of cropping practice, farmers can improve or harm environmental quality.	☐	☐	☐	☐	☐
I am familiar with the MSU recommended fertilizer rates for my farm.	☐	☐	☐	☐	☐

SECTION C. Your views on the importance of different possible environmental benefits linked to agriculture

C1. Please rate the following environmental effects on <u>how important they are for YOU as an individual</u>. *(Check the box of your choice.)*

	Highly Important to Me	Somewhat Important to Me	Not Important to Me
Increasing soil organic matter	☐	☐	☐
Increasing soil conservation	☐	☐	☐
Reducing phosphorus surface runoff	☐	☐	☐
Reducing nitrate leaching	☐	☐	☐
Reducing global warming	☐	☐	☐
Reducing pesticide risk to human health	☐	☐	☐

C2. Now, please rate the same environmental effects on <u>how important YOU believe they are to society</u>. *(Check the box of your choice.)*

	Highly Important to Society	Somewhat Important to Society	Not Important to Society
Increasing soil organic matter	☐	☐	☐
Increasing soil conservation	☐	☐	☐
Reducing phosphorus surface runoff	☐	☐	☐
Reducing nitrate leaching	☐	☐	☐
Reducing global warming	☐	☐	☐
Reducing pesticide risk to human health	☐	☐	☐

SECTION D. *Your adoption of farming practices on your corn-soybean acres*

CURRENTLY USING	*if you're currently practicing it right now on any corn-soybean land*
TRIED AND ABANDONED	*if you previously used the practice but gave it up*
NEVER TRIED	*if you've never tried it at any time*

D1. Please mark <u>your experience</u> using the practices below.

PRACTICES ON CORN SOYBEAN LAND	**Currently using**	**Previously tried and abandoned**	**Never tried**
No tillage for 4 or more consecutive years.	☐	☐	☐
No tillage in some years.	☐	☐	☐
Reduced tillage (compared to moldboard plow).	☐	☐	☐
Apply manure.	☐	☐	☐
Include wheat in corn-soy rotation.	☐	☐	☐
Plant any cover crop before corn.	☐	☐	☐
Plant legume cover crop before corn.	☐	☐	☐
Use PSNT to guide nitrogen application rate.	☐	☐	☐
Band apply N fertilizer over rows at MSU recommended rates, reducing total fertilizer use to 2/3 of full field rate.	☐	☐	☐
Apply only post-emergence herbicides (no pre-emergence).	☐	☐	☐
Scout for insect pests to guide pesticide decisions.	☐	☐	☐
Band apply herbicide and insecticide over rows at label rates, reducing total pesticide use to 2/3 of full field rate.	☐	☐	☐

SECTION E: Four specific cropping systems

Background:

We will show you four specific cropping systems.

We ask your views on environmental effects for the four cropping systems. We also ask about your willingness to accept payments to adopt the cropping systems.

The basic idea is that these systems may have some environmental benefits compared to conventional farming. Hence, there may be a reason to compensate farmers for any losses that they might incur by changing from their current practices to these practices.

We know there are actual programs that may be similar to the ones we describe, but we ask you to ***consider only the scenario we are proposing for each of the four cropping systems.***

The Program:

Imagine a program run by a non-governmental organization that would pay you each year for a 5-year commitment to adopt a particular cropping system. The practices that are required for each system are described. For a given set of practices, you choose the number of acres, if any, to enroll in the program.

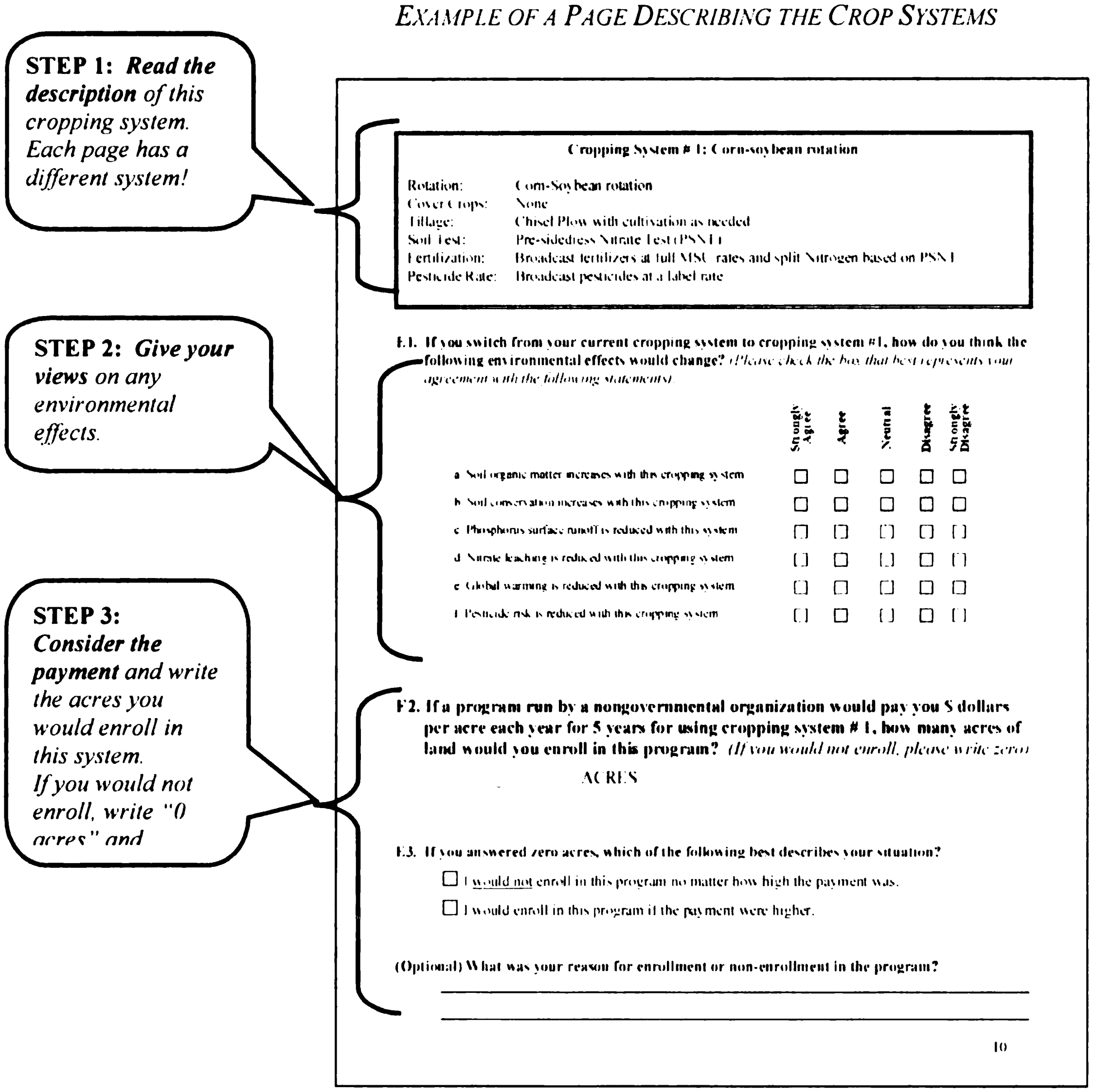
Key Points in answering:

- *When selecting the acres to enroll in a cropping system, consider each program separately -- as if the payment programs for the other three systems are unavailable.*
- *For crop rotations enrolled:*
  - *Corn-soybean-wheat rotation means ⅓ of the acreage in each crop every year.*
  - *Corn-soybean rotation means ½ of the acreage in each crop every year.*
- *If cover crops are included, they are on all enrolled fields during winter.*
- *Tillage refers to the principal tillage method on the enrolled acres.*
- *PSNT or pre-sidedress nitrate test is for the corn crop. Nitrogen fertilizer applied following PSNT is split rate (starter at planting and most at sidedress time).*

HOW TO ANSWER THE CROP SYSTEM QUESTIONS

This page provides an example of what you will see and how to answer

EXAMPLE OF A PAGE DESCRIBING THE CROP SYSTEMS



Cropping System # 1: Corn-soybean rotation

Rotation:	Corn-Soybean rotation
Cover Crops:	None
Tillage:	Chisel plow with cultivation as needed
Soil Test:	Pre-sidedress Nitrate Test (PSNT)
Fertilization:	Broadcast fertilizers at full MSU rates and split Nitrogen based on PSNT
Pesticide Rate:	Broadcast pesticides at a label rate

E1. If you switch from your current cropping system to cropping system #1, how do you think the following environmental effects would change? *(Please check the box that best represents your agreement with the following statements).*

Compared to my current cropping system,	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
a. Soil organic matter increases with this cropping system.	☐	☐	☐	☐	☐
b. Soil conservation increases with this cropping system.	☐	☐	☐	☐	☐
c. Phosphorus surface runoff is reduced with this system.	☐	☐	☐	☐	☐
d. Nitrate leaching is reduced with this cropping system.	☐	☐	☐	☐	☐
e. Global warming is reduced with this cropping system.	☐	☐	☐	☐	☐
f. Pesticide risk is reduced with this cropping system.	☐	☐	☐	☐	☐

E2. If a program run by a non-governmental organization would pay you $4 dollars per acre each year for 5 years for using cropping system #1, how many acres of land would you enroll in this program? *(If you would not enroll, please write zero).*

______________ ACRES

E3. If you answered zero acres, which of the following best describes your situation?

☐ I would not enroll in this program no matter how high the payment was.

☐ I would enroll in this program if the payment were higher.

(Optional) What was your reason for enrollment or non-enrollment in the program?

____

____

Cropping System #2: Corn-soybean rotation with cover crop	
Rotation:	Corn-Soybean rotation
Cover Crops:	Any type present over winter
Tillage:	Chisel plow with cultivation as needed
Soil Test:	Pre-sidedress Nitrate Test (PSNT)
Fertilization:	Broadcast fertilizers at full MSU rate and split Nitrogen based on PSNT
Pesticide Rate:	Broadcast pesticides at a label rate

E4. If you switch from your current cropping system to cropping system #2, how do you think the following environmental effects would change? *(Please check the box that best represents your agreement with the following statements).*

Compared to my current cropping system,	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
a. Soil organic matter increases with this cropping system.	☐	☐	☐	☐	☐
b. Soil conservation increases with this cropping system.	☐	☐	☐	☐	☐
c. Phosphorus surface runoff is reduced with this system.	☐	☐	☐	☐	☐
d. Nitrate leaching is reduced with this cropping system.	☐	☐	☐	☐	☐
e. Global warming is reduced with this cropping system.	☐	☐	☐	☐	☐
f. Pesticide risk is reduced with this cropping system.	☐	☐	☐	☐	☐

E5. If a program run by a non-governmental organization would pay you $10 dollars per acre each year for 5 years for using cropping system #2, how many acres of land would you enroll in this program? *(If you would not enroll, please write zero).*

_____________ ACRES

E6. If you answered zero acres, which of the following best describes your situation?

☐ I would not enroll in this program no matter how high the payment was.

☐ I would enroll in this program if the payment were higher.

(Optional) What was your reason for enrollment or non-enrollment in the program?

____

____

Cropping System # 3: Corn-soybean-wheat rotation with cover crop	
Rotation:	Corn-Soybean-Wheat rotation
Cover Crops:	Any type present over winter
Tillage:	Chisel plow with cultivation as needed
Soil Test:	Pre-sidedress Nitrate Test (PSNT)
Fertilization:	Broadcast fertilizers at full MSU rate and split Nitrogen based on PSNT
Pesticide Rate:	Broadcast pesticides at a label rate

E7. If you switch from your current cropping system to cropping system #3, how do you think the following environmental effects would change? *(Please check the box that best represents your agreement with the following statements).*

Compared to my current cropping system,	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
a. Soil organic matter increases with this cropping system.	☐	☐	☐	☐	☐
b. Soil conservation increases with this cropping system.	☐	☐	☐	☐	☐
c. Phosphorus surface runoff is reduced with this system.	☐	☐	☐	☐	☐
d. Nitrate leaching is reduced with this cropping system.	☐	☐	☐	☐	☐
e. Global warming is reduced with this cropping system.	☐	☐	☐	☐	☐
f. Pesticide risk is reduced with this cropping system.	☐	☐	☐	☐	☐

E8. If a program run by a non-governmental organization would pay you $15 dollars per acre each year for 5 years for using cropping system #3, how many acres of land would you enroll in this program? *(If you would not enroll, please write zero).*

_____________ ACRES

E9. If you answered zero acres, which of the following best describes your situation?

☐ I <u>would not</u> enroll in this program no matter how high the payment was.

☐ I would enroll in this program if the payment were higher.

(Optional) What was your reason for enrollment or non-enrollment in the program?

____

____

Cropping System # 4: Corn-soybean-wheat with cover crop and reduced rates of fertilizer & pesticides	
Rotation:	Corn-Soybean-Wheat rotation
Cover Crops:	Any type present over winter
Tillage:	Chisel plow with cultivation as needed
Soil Test:	Pre-sidedress Nitrate Test (PSNT)
Fertilization:	Band apply fertilizers over row at MSU rate and split Nitrogen based on PSNT
Pesticide Rate:	Band apply pesticides over row at label amount

E10. If you switch from your current cropping system to cropping system #4, how do you think the following environmental effects would change? *(Please check the box that best represents your agreement with the following statements).*

Compared to my current cropping system,	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
a. Soil organic matter increases with this cropping system.	☐	☐	☐	☐	☐
b. Soil conservation increases with this cropping system.	☐	☐	☐	☐	☐
c. Phosphorus surface runoff is reduced with this system.	☐	☐	☐	☐	☐
d. Nitrate leaching is reduced with this cropping system.	☐	☐	☐	☐	☐
e. Global warming is reduced with this cropping system.	☐	☐	☐	☐	☐
f. Pesticide risk is reduced with this cropping system.	☐	☐	☐	☐	☐

E11. If a program run by a non-governmental organization would pay you $20 dollars per acre each year for 5 years for using cropping system #4, how many acres of land would you enroll in this program? *(If you would not enroll, please write zero).*

_____________ ACRES

E12. If you answered zero acres, which of the following best describes your situation?

☐ I would not enroll in this program no matter how high the payment was.

☐ I would enroll in this program if the payment were higher.

(Optional) What was your reason for enrollment or non-enrollment in the program?

____

____

SECTION F: This last section asks for background information to help identify patterns among different kinds of farms. Your answers will be kept completely confidential.

F1. What is your age? ___________ YEARS

F2. What is your gender?

☐ Male

☐ Female

F3. How long have you been farming? ___________YEARS

F4. `Other than yourself, how many members of your household are in each of these age groups?

______ Members under 18

______ Members Ages 18 to 30

______ Members Ages 31 to 64

______ Members Ages 65 and over

F5. Is farming the main source of income for your household?

☐ Yes

☐ No ⟹ If NO, what is your main source of income?

____

F6. What was the total household income of the principal operator in 2007? *(Include net income from farming, wage or salary income from all sources, social security and investment income.)*

☐ Less than $20,000

☐ $20,000 to $39,999

☐ $40,000 to $59,999

☐ $60,000 to $79,999

☐ $80,000 to $99,999

☐ $100,000 and above

F7. How much cropland did you farm during 2007? And how much was irrigated?

Owned land: ___________ (ACRES) of which irrigated = __________ (ACRES)

Rented land: ___________ (ACRES) of which irrigated = __________ (ACRES)

F8. Is your farm certified under the Michigan Agricultural Environmental Assurance Program (MAEAP), including farming system and cropping system?

☐ No

☐ Yes

F9. What is the zip code of your farm? ______________________

NEXT PAGE ⟹

F10. Have you ever participated in any of the following conservation program?

	No	Yes
a. Environmental Quality Incentives Program (EQIP)	☐	☐
b. Conservation Reserve Program (CRP)	☐	☐
c. Conservation Security Program (CSP)	☐	☐

F11. What is the highest level of education you have completed?

☐ Less than 12 years
☐ High school diploma
☐ Technical training beyond high school
☐ Some college (including AA, AS degrees)
☐ 4-year college degree
☐ Some graduate work
☐ Graduate degree

F12. Is land use in any of your farm fields restricted? *(Check all that apply.)*

☐ Unrestricted
☐ Restricted, Agricultural (PA 116, conservation easement, purchase of development rights, etc.)
☐ Restricted, Residential
☐ Restricted, Industrial

F13. What is your farm's form of business organization?

☐ Sole proprietorship
☐ Partnership
☐ Limited Liability Corporation (LLC)
☐ Small Corporation (subchapter S)
☐ Corporation (subchapter C)

F14. How many more years do you expect to continue farming? __________YEARS

F15. Do you intend to pass on the farm to a family member or a close friend?

☐ No
☐ Yes

THANK YOU!

If you have questions, please contact Scott A. Swinton at 1-517-353-7218, by e-mail at swintons@msu.edu, or by postal mail at Department of Agricultural Economics, Michigan State University, East Lansing, MI 48823-1039.

Crop Management and Environmental Stewardship Survey
Department of Agricultural Economics
306 Agriculture Hall
Michigan State University
East Lansing, MI 49924 -9904

MICHIGAN STATE
UNIVERSITY

FARMER NAME
Address

February __, 2008

Last week a questionnaire about crop management and environmental stewardship was mailed to you. Your name was drawn from a random sample of corn farmers in Michigan.

If you have already replied, thank you very much. If not, please do so today. We have sent the questionnaires to only a small but representative sample of Michigan corn-soybean growers. It is very important that you reply so that the results give the clearest possible picture of how decisions on crop management and environmental stewardship practices are made in Michigan.

If by any chance you did not receive the questionnaire, or it was misplaced, please call me collect at 517-353-7218, and I will replace it right away.

Sincerely,

Scott Swinton
Project Coordinator

COLLEGE OF
AGRICULTURE AND
NATURAL
RESOURCES
Department of Agricultural
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Michigan State University
202 Agriculture Hall
East Lansing, MI
48824 1039
Fax 517/432 1800
Web www.aec.msu.edu/agecon

March 14, 2008

Dear Michigan Corn and Soybean Producer,

About four weeks ago, I wrote to ask your opinions on cropping practices and the environment. As of yesterday I had not yet received your completed questionnaire.

We have undertaken this study to ensure that the design of future agro-environmental policies is informed by the views and concerns of Michigan farmers.

I am writing to you again because each questionnaire really matters for this study. Your farm is one of the small number of farms drawn from a scientific sampling process. In order for the results of this study to fairly represent the opinions of all Michigan farmers, it is very important that each farmer in the sample return their questionnaire. As mentioned in our last letter, the questionnaire *the person who makes the crop management decisions* on the farm.

In the event that your questionnaire has been misplaced, I enclose a replacement.

As I mentioned in the earlier letter, your individual views will be completely confidential and your privacy will be protected to the maximum extent permitted by law. Also, your participation in the survey is voluntary, and you may refuse to answer certain questions. If you have any questions or concerns regarding your rights as a study participant, you may contact Peter Vasilenko, Ph.D., Director of Human Research Protection Programs at Michigan State University by phone: (517) 355-2180, or by email: irb@msu.edu.

I would be happy to answer any questions you might have. Just call me at 1-517-353-7218 or email me at swintons@msu.edu.

Spring is not far off. I know you have lots to do, but I do hope that you can carve out 20 minutes to let us know your thoughts. Thanks in advance for your cooperation on this.

Sincerely,

Scott Swinton
Professor

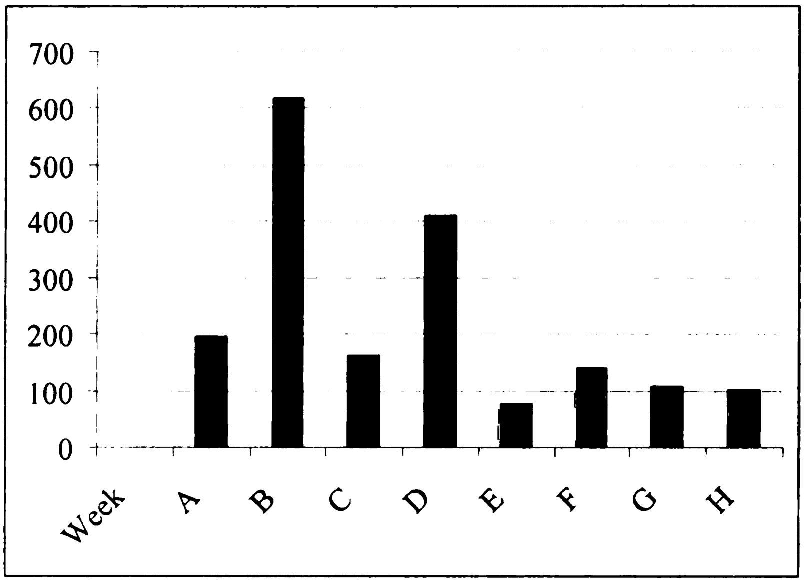
P.S. If your farm no longer grows corn and soybean, please answer just the first question and return the questionnaire in the prepaid envelope.

APPENDIX EIGHT: Survey Returns, Response Rate and Completion Status

SURVEY RETURNS, RESPONSE RATE AND COMPLETION STATUS

Returned surveys were counted to track sample status and response rate. Peak survey returns occurred a few days after each mailing and illustrate the importance of multiple mailings to ensure a high response rate. Figure 1 shows the number of returned surveys each week.

Appendix Figure 1. Number of Returned Surveys By Week



LEGEND:

A - Feb 16

B - Feb 22

C - Feb 27, 28

D - Mar 6, 7

E - Mar 11, 14

F- Mar 19, 21

G - Mar 24, 26, 28,

H - May 16

Questionnaires were completed and returned by 1747 individuals. An additional 59 individuals returned the survey but refused to answer, 1194 surveys were not returned, and 5 were eliminated from the sample for the reasons listed in Appendix Table 12 next page. The net response rate was 56.36 %.

Appendix Table 12. Final Status of the Survey about Crop Management and Environmental Stewardship

Status	Number	Percent
Surveys returned (Returned and answered)	1747	58.23 %
Refusals (Returned but refused to answer)	59	1.97 %
Surveys not returned	1194	39.80 %
Eliminated:		
Undeliverable	2	0.07 %
Deceased	3	0.10 %
TOTAL SENT	3000	100 %

COMPLETED QUESTIONNAIRES = Surveys Returned – Refusals = 1688

NET RESPONSE RATE $= \frac{\text{Completed Questionnaires}}{\text{Total Sent-eliminated}} \times 100 = 56.36\%$

APPENDIX NINE: Survey Weights

SURVEY WEIGHTS

Since each stratification level is representative of an unequal number of farmers, the survey design results in unequal selection of probabilities. In order to estimate descriptive statistics that are representative of the target population and avoid sample bias, each observation must be appropriately weighted.

The sample weight corrects for the difference in selection probabilities by stratum. To determine the sample weight, observe that each stratification level i (where i = 1 to 4) represents a separate subsample, s_i from the total sample, S , and that the total population represented by each stratum is given by n_i from the total population of N (Deaton, 1997). We can define the weight, w_i, for farmer i as the ratio of true shares to sample shares,

$$w_i = \frac{n_i / N}{s_i / S} \qquad (1)$$

where the true shares, n_i / N, and sample shares, s_i / S, represent the selection probabilities from a simple random sample and from our stratified sample. These survey weights ensure that the sample should sum to the sample size and average to one (where these sums and averages are taken across the 1688 cases). Appendix Table 13 presents the sample selection and sample weight calculation by stratum.

Reference:

Deaton, A. 1997. *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy.* The World Bank: Washington, DC.

Appendix Table 13. Stratified Random Sample Design and Weights Calculation

Strata	Acres	Number of Farmers	Number of Sampled Farmers within each Strata	True Shares	Sample Shares	Survey Weights
		n_i	s_i	n_i / N	s_i / S	$w_i = \frac{n_i / N}{s_i / S}$
1	0-100	9849	301	0.5585	0.1003	5.5667
2	101-500	5545	1050	0.3144	0.3500	0.8984
3	501-1000	1361	770	0.0772	0.2567	0.3007
4	1000+	879	879	0.0498	0.2930	0.1701
		17634	3000			

* Note: Probability Sampling was from National Agricultural Statistics Service (NASS), Michigan Field Office and the Survey Weights was calculated by the author.

APPENDIX TEN: Some Descriptive Results from the Farm Survey (Essay 2)

Adoption of several individual cropping practices is shown in Appendix Table 14. A large portion of farmers has never tried no tillage during 4 or more consecutive years, although a large portion are currently using no tillage in some years. Moreover, large percentages of farmers are currently using reduced tillage, manure application, wheat in rotation, post-emergence herbicides and scouting for pests. Large percentages of farmers have never tried cover crops, PSNT to guide nitrogen application rate and band application of herbicides.

Appendix Table 14. Corn and Soybean Land Practices Adoption (unweighted)

	Currently Using	Previously Tried and Abandoned	Never Tried
No tillage for 4 or more consecutive years	31%	15%	53%
No tillage in some years	55%	19%	26%
Reduced tillage (compared to moldboard plow)	82%	12%	6%
Apply manure.	56%	17%	27%
Include wheat in corn-soy rotation	65%	18%	17%
Plant any cver crop before corn	19%	26%	55%
Plant legume cover crop before corn	15%	19%	65%
Use PSNT to guide nitrogen application rate.	19%	16%	65%
Band apply N fertilizer over rows at MSU recommended rates, reducing total fertilizer use to 2/3 full field rate.	22%	10%	69%
emergence)	55%	25%	20%
Scout for insect pests to guide pesticide decisions.	87%	4%	9%
Band apply herbicide and insecticide over rows at label rates, reducing total pesticide use to 2/3 of full field rate.	21%	24%	55%

Source: Crop Management and Environmental Stewardship Survey

Some of these practices are bundled into 4 different cropping systems as presented in section Table2.1 and used in the survey questionnaire.

Reasons for taking part and not taking part in the proposed programs are given in Appendix Table 15 and Appendix Table 16. An optional open ended question on reasons for non-enrollment was presented after the dichotomous questions. Clearly, based on the frequencies in Appendix Table 15, profitability of the system or the financial and practical reasons seem to be most important for non-enrollment. Farmers said that some of the practices in the cropping system offered to them are not feasible due to lack of physical capital.

Appendix Table 15. Frequency of Reasons for not taking part in the countryside stewardship measures (unweighted)

I did not enroll because ...	Cropping System A	Cropping System B	Cropping System C	Cropping System D
I do not find it profitable.	462	401	349	314
I do not agree with activity(s) in this system. It is not feasible in my case (I.e. lack of physical capital, etc.)	326	296	257	381
This practice does not do any good for the environment. I do not believe that I am a direct contributor for global warming!	13	2	3	6
There's too much control and too much hassle.	46	36	32	51
I do not want to deal with the government.	19	16	20	32
This is risky.	9	4	11	20
I am about to retire.	14	9	9	14
I need more information.	16	17	20	21

Source: Crop Management and Environmental Stewardship Survey

Appendix Table 16. Frequency of Reasons for taking part in the countryside stewardship measures (unweighted)

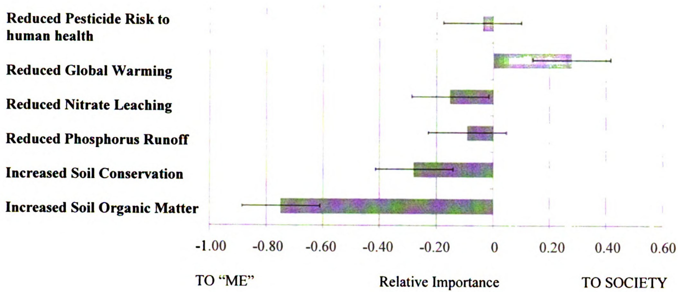
I enrolled because...	Cropping System A	Cropping System B	Cropping System C	Cropping System D
I am currently doing this.	93	34	42	37
I just want to try it out.	35	90	107	63
This is really good, economically and environmentally.	14	5	16	35

Source: Crop Management and Environmental Stewardship Survey

A small number of farmers also did not recognize the link with protecting the environment or indicated that they do not believe that their farming is a direct contributor to global warming as shown in Appendix Table 15.

Appendix Figure 2 presents the frequencies on how the farmers saw the importance of different ecosystem services for the individual and the society. Using a 3 point likert-scale of importance where 1-highly important, 2- somewhat important and 3- not important; so when difference (society rating minus individual rating) were taken, negative values meant more important to individual point than to society. The ecosystem services were increasing soil organic matter, increasing soil conservation, reducing phosphorus surface run off, reducing nitrate leaching, reducing global warming and reducing pesticide risk to human health. Farmers rated the increased soil organic matter, enhanced soil conservation, reduced phosphorus runoff, reduced nitrate leaching and reduced pesticide risk more important to themselves than society with 0.01 significance levels for paired difference t-tests. By contrast, reduced global warming was found to be much more important to society than to themselves. Benefits from soil organic matter and soil conservation contribute directly to crop productivity. Reduced global warming has the most diffused benefits of all.

Appendix Figure 2. Relative Importance of Selected Ecosystem Services to Individual and Society (unweighted)



From the reasons listed in Appendix Table 15, some farmers find that there is too much in the type of program being offered and a portion of farmers even said that they did not want to deal with the government. In fact a number of farmers mentioned that they are enrolling a small portion of their land just to try the program out. They feared less flexibility if enrolled in the program. In Appendix Table 16, farmers who enrolled in the program are either doing almost the same cropping system or they believed in the benefits of the system.

Although Appendix Tables 14, 15 and 16 were unweighted numbers and frequencies, they clearly illustrate that there is a portion of farmers who are willing to adopt, but the follow up question on reasons for decision revealed that there is also a portion of farmers who are still not convinced about the appeal of such measures. The big difference in reaction to both questions – the higher non-participation and negative reactions – and the link between the farmers' characteristics- are further analyzed in the probit model and truncated models in the text.

Appendix Table 17 shows the weighted mean estimates the two categories of sample respondents differ in various aspects. It also presents also the p-values for an equality mean t-test between participants and non-participants.

Appendix Table 17. Mean Levels and Mean-Difference T-test Between Participants and Non-Participants By Cropping Systems (weighted by Farm Size Stratum)

Variable	Unit or Type	CROP SYSTEM A Mean Value		P-Value	CROP SYSTEM B Mean Value		P-Value	CROP SYSTEM C Mean Value		P-Value	CROP SYSTEM D Mean Value		P-Value
		Yes	No	a/	Yes	No	a/	Yes	No	a/	Yes	No	a/
Acres enrolled	Acres	222.63	0		216.46	0		185.50	0		194.19	0	
Version													
Government	Dummy	0.5509	0.5232		0.5391	0.5254		0.5637	0.5086		0.5104	0.5412	
Descending Sequence	Dummy	0.3565	0.5779	**	0.4073	0.5735	***	0.4222	0.6004	***	0.5807	0.5044	
Payment	Dollars	10.690	10.008	***	27.263	23.206	***	39.991	32.708	***	50.049	48.129	***
Perceived Environmental Performance	Likert 1-5	3.4389	2.9669	***	3.5775	3.2408	***	3.8990	3.3550	***	3.9261	3.4221	***
Biophysical Variables													
Sandy Soil	Dummy	0.3787	0.3055		0.3675	0.3054		0.3325	0.3119		0.3101	0.3259	
Silty Soil	Dummy	0.0128	0.0456		0.0308	0.0419		0.0251	0.0475		0.0459	0.0348	
Clay Soil	Dummy	0.5191	0.5101		0.4534	0.5288		0.4911	0.5235		0.5215	0.5050	

Cont'd Appendix Table 17. Mean Levels and Mean-Difference T-test Between Participants and Non-Participants By Cropping Systems (weighted by Farm Size Stratum)

Variable	Unit or Type	CROP SYSTEM A Mean Value		P-Value	CROP SYSTEM B Mean Value		P-Value	CROP SYSTEM C Mean Value		P-Value	CROP SYSTEM D Mean Value		P-Value
		Yes	No	a/	Yes	No	a/	Yes	No	a/	Yes	No	a/
Current Practices													
Moldboard tillage	Ratios	0.0428	0.1919	***	0.0307	0.2024	***	0.0813	0.2103	***	0.0968	0.2113	***
No till tillage	Ratios	0.2059	0.1113	***	0.2445	0.0956		0.1917	0.0937		0.1836	0.0905	
Conservation tillage	Ratios	0.3778	0.3455	***	0.3632	0.3482		0.3440	0.3559		0.3683	0.3398	
Wheat	Ratios	0.0784	0.0977	**	0.1020	0.0917		0.1139	0.0828	***	0.0942	0.0939	***
Cover Crops	Ratios	0.0539	0.0764	*	0.0472	0.0794		0.0780	0.0688		0.0678	0.0752	*
Total Land Managed	Acres	613.26	416.02	**	555.89	423.49	**	504.046	424.610		472.92	439.37	
Expected Prices													
Wheat to Corn price ratio	Ratios	1.8109	1.7044		1.7560	1.7154		1.6823	1.0484	*	1.7532	1.7042	
Wheat to Soybean price ratio	Ratios	0.7523	0.8165		0.7424	0.8224		0.8551	0.7757		0.8690	0.7585	

Cont'd Appendix Table 17. Mean Levels and Mean-Difference T-test Between Participants and Non-Participants By Cropping Systems (weighted by Farm Size Stratum)

Variable	Unit or Type	CROP SYSTEM A Mean Value Yes	CROP SYSTEM A Mean Value No	CROP SYSTEM A P-Value a/	CROP SYSTEM B Mean Value Yes	CROP SYSTEM B Mean Value No	CROP SYSTEM B P-Value a/	CROP SYSTEM C Mean Value Yes	CROP SYSTEM C Mean Value No	CROP SYSTEM C P-Value a/	CROP SYSTEM D Mean Value Yes	CROP SYSTEM D Mean Value No	CROP SYSTEM D P-Value a/
Environmental Program Experience													
MAEAP	Dummy	0.1147	0.1306		0.0525	0.1494		0.1189	0.1326		0.0879	0.1556	***
EQIP	Dummy	0.1797	0.1355		0.1630	0.1383	*	0.2122	0.1053		0.2135	0.0944	***
CRP	Dummy	0.2917	0.1934		0.2549	0.1995		0.2618	0.1828	**	0.2530	0.1829	*
CSP	Dummy	0.0634	0.0674		0.0595	0.0688		0.0872	0.0551		0.0635	0.0689	
Demographics													
Age	Years	57.412	58.238	***	55.751	58.526	***	55.094	55.424	**	53.205	54.610	***
Education Years	Years	14.251	13.538	**	14.601	13.404	**	14.276	13.332	**	13.893	13.517	**
		N=642			N=639			N=647			N=656		

a/ P-values for mean-difference t-test between participants and non-participants assuming equal variances.

***- significant at 1% level, **-significant at 5% level, *-significant at 10% level

Note: Mean value constructed from six Likert scale variables for level of agreement that proposed cropping system would improve environmental performance compared to farmer's current system (1=strongly disagree; 5=strongly agree)