LANDOWNER WILLINGNESS TO SUPPLY MARGINAL LAND FOR BIOENERGY PRODUCTION IN MICHIGAN

By

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ABSTRACT

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Growing bioenergy crops on non-crop, marginal land offers an avenue to escape the ethical and practical limitations of using cropland, but how much of this land are owners actually willingly make available? A contingent valuation survey was used to examine the willingness of landowners to supply land for bioenergy crop production. Owners of non-crop marginal land were identified using area-frame sampling, based upon the 2010 USDA Cropland Data Layer (CDL) of land cover. Willingness to supply land was estimated econometrically as a survey-weighted hurdle model comprised of a participation decision probit and an acreage commitment truncated regression.

The results reveal two significant findings. First, landowners who possess non-crop marginal land on average own more cropland than non-crop land and given the opportunity to rent out either land type for bioenergy crops, they preferred to rent out more cropland. This result highlights how markets for land at the extensive margin inherently link the supply of bioenergy crops to that of food crops. Second, even at high rental rates, less than a third of landowners were willing to rent out their marginal land to grow bioenergy crops. This finding suggests that the supply of marginal land for bioenergy crops is more limited than previously believed, at least based on evidence from Michigan.

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To God be the Glory.

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Chapter 1: Background on Bioenergy

Bioenergy is any form of energy that comes from a biological source. These biological sources are referred to as biomass. Bioenergy can come in the form of a solid or a liquid. Historically, bioenergy came from a solid by burning biomass such as wood. Recently, the liquid forms of bioenergy have been growing and are known as biofuels. Biofuels often serve as substitute fuels for more conventional fuels. For example, ethanol is a biofuel substitute for gasoline and biodiesel is a biofuel substitute for diesel.

The most plentiful biofuel in the United States is corn grain ethanol. In 2011 the United States produced 13.9 million gallons of ethanol (Renewable Fuels Association 2012). Corn grain ethanol is the leading focus in the U.S. because corn grows well in the region, its starches are relatively easy to convert into ethanol, and infrastructure and harvesting equipment already exist for the grain. Brazil is the second largest producer of ethanol and uses sugar cane as biomass for similar reasons (Renewable Fuels Association 2012). However, ethanol can be produced from other sources as well. The largest potential source for production is cellulosic biomass. Cellulose is a basic organic compound comprising much of the structural material found in plants. Cellulosic ethanol is desirable in its ability to utilize many different sources of biomass. The current issue to mass production of cellulosic ethanol is the high infrastructure and processing costs associated with converting cellulose into a fuel (USDA and DOE, 2000).

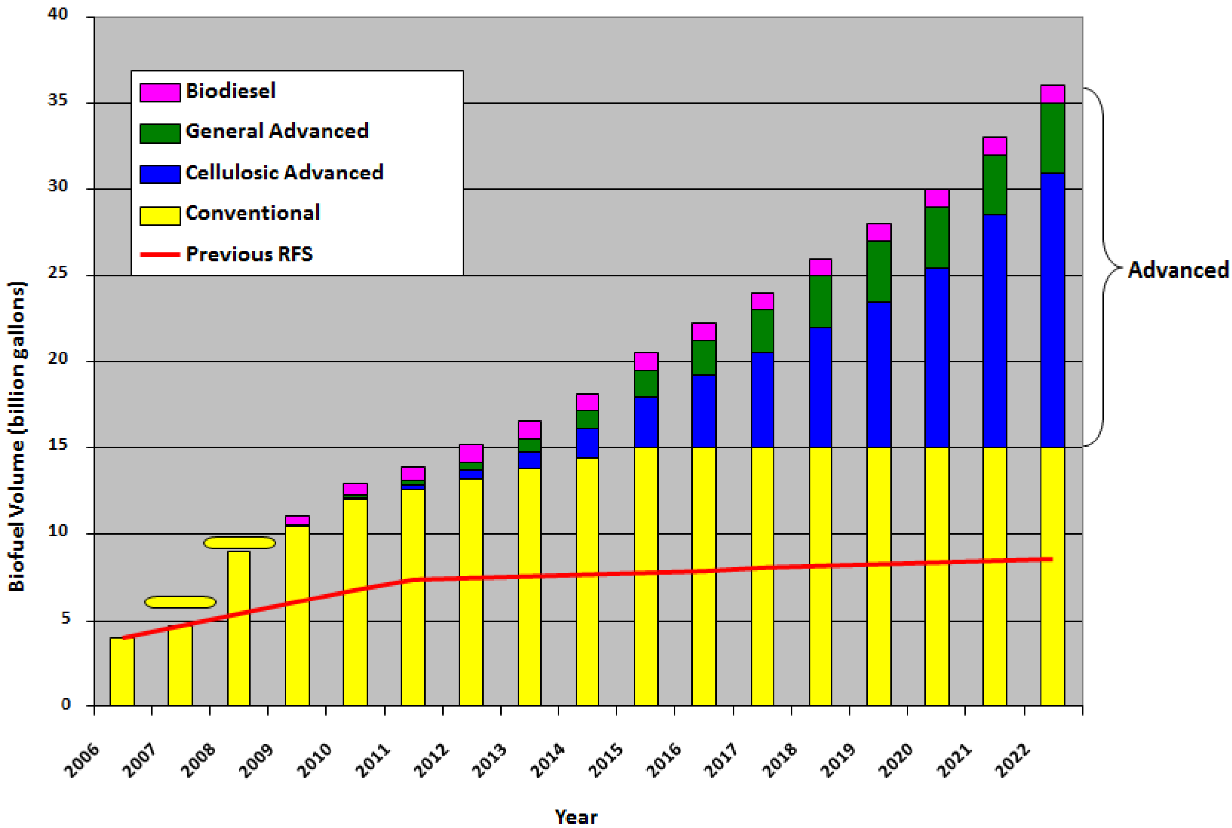
This study focuses on cellulosic biomass with the anticipation that these costs could decrease in the future.

1.1 Why Bioenergy?

Ever since the creation of the Renewable Fuel Standard (RFS) program in 2005 U. S. demand for bioenergy has dramatically increased. In 2007 under the Energy Independence and Security Act (EISA), the RFS was expanded to increase the percent of ethanol blended into gasoline. Also at that time an important distinction was made between different types of ethanol and separate volume mandates were created for each source (EPA 2007). Advanced biofuels such as cellulosic ethanol were specifically mandated. Figure 1 shows the previous standards and how they were increased through 2022.

While the federal government was increasing demand for biofuels, many states have been increasing the demand for bioenergy in the form of electricity. Thirty out of the 50 states as well as the District of Columbia have set Renewable Portfolio Standards (RPS). These standards mandate that a certain percentage of electricity within the state come from a renewable source such as wind, solar, geothermal, and biomass. New York has one of the highest and fastest goals with a RPS mandate of 25% of electricity coming from renewable sources by 2013. Maine is also very high with an RPS set at 40% of electricity coming from renewable sources by 2017. In the case of Michigan, where this study is focused, a RPS was introduced that mandated 10% of Michigan electricity to be from renewable sources by 2015.

Figure 1. Federal Renewable Fuel Standards with Advanced Biofuels 2006-2022



What is driving this desire to increase bioenergy? There are three main perceived benefits of bioenergy. First, bioenergy is a form of renewable energy meaning that similar to wind and solar energy the supply can be renewed. This is a major difference from conventional sources of energy that are often fossil fuel based and have a limited supply. Second, bioenergy has been shown to be potentially carbon neutral through its lifecycle. Carbon neutral means that during its lifecycle a bioenergy feedstock may add carbon dioxide to the atmosphere but it also removes carbon dioxide, making a net neutral effect. For example in the case of cellulosic ethanol, the amount of carbon dioxide produced when burning the fuel in an automobile is offset by the amount of carbon dioxide sequestered through growing cellulosic biomass (Slade, Bauen and Shah 2009). Debates exist on under what conditions this may or may not hold true but according to Sedjo (2011) the literature shows that over the long term bioenergy is a carbon neutral source of energy. The National Research Council (NRC) in 2011 also notes that carbon emissions and reductions can vary, depending on the bioenergy source (food-based biofuels or dedicated biofuel crops) and on where the biomass is grown. The third benefit associated with bioenergy in the United States, is as a route to energy independence for national security. The Energy Independence and Security Act (EISA) (110. P.L. 140) says, "(the goal of the Act was) to move the United States toward greater energy independence and security". U.S. grown bioenergy feedstocks make the United States less dependent on foreign sources of energy.

Chapter 2: Why Marginal Land?

Land is an essential input to produce bioenergy at a large scale and a resource with a limited supply. It is used to produce food, feed, lumber, paper products and ecological services. Using existing cropland to grow bioenergy crops would increase the demand for cropland. Studies have shown that some harmful consequences exist when increasing competition for cropland. Searchinger et al. (2008) describe how using current land that is in corn to grow bioenergy crops could increase greenhouse emissions by 50%. Rajagopal et al. (2007) found that in the long run by competing for cropland bioenergy production can decrease the supply of food. In 2008, Fritsche detailed the potential greenhouse gases from direct and indirect land use change that would occur from converting cropland to bioenergy crops. In a report to the UK government, Gallagher (2008) echoes the concerns earlier mentioned. He notes the potential for increases in food prices and greenhouse emissions as indirect effects of growing bioenergy crops on existing cropland. Using cropland for biofuel would also lead to a direct connection between prices in the energy markets and prices in the food markets as both industries would be in direct competition for cropland (Piroli, Ciain and Kancs 2011). It can be seen then, that increasing competition for cropland by growing bioenergy crops can have serious, negative side effects.

Growing bioenergy crops on marginal land offers a way to avoid the problems associated with those crops on cropland. By occupying land that is not used for crops, bioenergy crop production on marginal land could ease the increasing demand for cropland and thus has a lesser effect on food prices (Swinton et al. 2011; Campbell et al. 2008; Carroll and Somerville 2009; Tilman et al. 2009).

2.1 Land for Biomass

Land for biomass can come from the intensive margin or the extensive margin. Biomass from the intensive margin is any additional biomass that comes from existing cropland. There are two ways to get more biomass from existing cropland. First, dedicated bioenergy crops could be grown instead of existing crops. For example switchgrass is a high yielding cellulosic based bioenergy crop that could be planted on existing cropland that is in use growing corn, soybeans, or other crops. Alternatively, it is also possibly to get more bioenergy from the intensive margin by increasing inputs and removing more biomass. Corn stover is a term used for all the other parts of the corn plant besides the grain, such as husks and stalks (Sheehan et al. 2008). Corn stover is currently left on many fields to restore nutrients the ground for the next crop to use; however, it is cellulose-based and studies show that removal up to 50% was not only provide biomass but also give a yield advantage (Jeschke 2011).

The extensive margin refers to expansion of biomass production onto land that is currently not used for crop production. For example an expansion onto the extensive margin could be clearing a piece of scrubland that is lying idle and growing a dedicated cellulosic biofuel crop such as switchgrass on it. Land on the extensive margin may have a variety of different types of land cover and may not be in crops for a variety of reasons. The only defining characteristic about this land is that it is not used for crops.

2.2 Defining Marginal Land for this Study

As described earlier, one of the main concerns with growing bioenergy crops is that they may compete for cropland. Therefore, when we talk about how growing bioenergy crops on marginal land has the benefit of not competing with other crops for cropland, it is important that we clearly define what land we are talking about.

Above we discussed the extensive margin and intensive margin. The extensive margin is exactly the land we are defining as marginal land in this study. This marginal land is land that is defined as such purely based upon how it is used. It is land that does not contribute to crop production in any way and therefore its use for bioenergy crops will not affect cropland use. This is an economic understanding of word marginal and as Laura James, notes it dates back to Barlowe (1986) and Peterson and Galbraith (1932) (James 2010).

Throughout the history of the bioenergy discussion, the definition of marginal land has varied; therefore, it is important to be clear about what we are not defining as marginal land. There is another definition of marginal land that others use. It is based upon the land's "quality" or ability to produce agriculturally. In general this refers to land that is less fertile based upon a number of biophysical measurements. This is land that might be sandier, rocky, contain fewer nutrients, be susceptible to erosion or have varying elevation (Peterson Galbraith 1932; Dangerfield and Harwell 1990; Lal 2005).

To understand why a distinction between these definitions of marginal land is so important we must remember that growing biomass on cropland would raise food prices so ideally biomass would be grown on non-cropland. There are two main reasons this lower fertility definition of marginal land is discussed when talking about bioenergy. The first reason is that cellulosic based bioenergy crops, when compared to typical crops, require less fertile land and often fewer inputs making them more ideal for this type of biophysically marginal land (Tilman et al. 2006; Perlack et al. 2011). This is definitely a positive trait of dedicated cellulosic based bioenergy crops but not all land that is less fertile lays idle. It is important to remember here that ideally bioenergy crops are grown on non-cropland, land not necessarily less fertile land. Landowners vary and so do their choices. Land with the same level of fertility may be in crops under one manager and not in crops under another. Some land may simply not be in use because it is inaccessible by farm equipment and some land may be in crops because it is close to a granary bringing down transportation costs. This leads to the other reason this lower fertility definition of marginal land is often discussed when talking about bioenergy. There is a misconception that land currently not being used for crops, is in the extensive margin solely because it is less fertile. While it is often the case that less fertile land is not used for growing crops, there are many other reasons land may not be crops. As mentioned earlier, landowners make the decision what land is used to grow crops and what land is not. No matter what the land quality may be, if the land contributes to growing crops, using it for biomass instead will have an effect on price of food. There are a number of studies including the Billion-Ton report completed by the Department of Energy (DOE) that cite marginal land as having the benefit of not displacing cropland, yet still when describing marginal land they define it based upon biophysical characteristics such as salinity (U.S Department of Energy 2011). This can result in a misleading amount of land being cited as available to grow bioenergy crops without disrupting crop prices and can cause misidentification if landowners of this type of less fertile marginal land are solicited for a willingness to supply marginal land study.

Part of this study's focus is to examine the possibility of growing bioenergy crops in a way that avoids using cropland. To do this we clearly focus on eliciting landowners' willingness to supply land that is marginal because it is part of the extensive margin and not in crop production. This leads us to a full description of the objectives of this study below.

Chapter 3: Goals and Objectives

The goal of this research is to examine the availability of marginal land to grow bioenergy crops through eliciting landowners' willingness to supply marginal land for bioenergy crops. In order to reach this goal a series of objectives were identified.

1. Elicit landowners' willingness to supply their land for bioenergy crops.
    a. Identify landowners who own over 10 acres of marginal land, land not used for crops or in forest.
    b. Identify how much land under different current uses these landowners are willing to make available for bioenergy crops.
2. Describe the potential supply of land to grow bioenergy crops.
    a. Describe how willing the average landowner is to supply their land for bioenergy crops.
    b. Scale the average landowners' response up to an area of interest to describe how much marginal land would be available for bioenergy crops in that region.
    c. Identify what factors have a significant effect on landowners' decisions.
    d. Identify which bioenergy crops may be preferred, if any.
    e. Identify whether landowners have a preference on renting cropland or marginal land.

Chapter 4: Conceptual Framework

The conceptual framework for this study focuses on how land use decisions are made. Land is managed by landowners who make decisions on how it will be used. These decisions are driven by a desire from the landowner to maximize personal utility. In 1981, Binkley modeled household decisions on forest management citing that the land produced both timber and other amenity values. Timmons in 2011 extended this idea to landowners' decisions to produce biomass. The basic concept of his work being that landowners can receive utility from both consumption and amenities that come from land and that they will choose a combination of both that maximizes their utility.

Utility from consumption can result from income being used to purchase consumable goods (Timmons 2011); however, consuming purchased goods are not the only way to receive utility. Individuals benefit from tangible and intangible amenities. For example the utility received through a friendship is an intangible amenity, while the utility received from swimming in a lake would be a tangible amenity.

Income for consumption can come from a variety of sources. Income can come from salary, wages, social security, rental properties, investments, or any other income generating source. The income of landowners does not have to solely come from land. Many households that own land have members who work at jobs unrelated to agriculture for a primary source of income. When income does come from land, it can come in a variety of ways. A landowner can rent their land to a farmer or choose to farm the land directly for income.

Amenities from land can take a variety of forms. Some people value their land for the scenery, for hunting or fishing, for recreational vehicle use, or for physical activities. Whatever these amenities might be it is clear that through a land use change such as growing bioenergy crops the value received from each amenity can change. Depending on how the amenity relates to the type of land use, the value from that amenity could increase, decrease, or have no change. For example when an open field used for hunting deer is changed to grow poplar trees it may no longer attract deer or provide the sight lines necessary for hunting them thus decreasing the potential value of hunting on the land. Like income, amenities do not solely come from land. Landowners can get amenity value from other sources as well, such as family or use of a public bike path.

Table 1. Conceptual Model Variables

Variable Description	Name	Symbol
Utility of an individual landowner	Utility	*U*
Income of an individual landowner	Income	*m*
Amenities of an individual landowner	Amenities	*a*
Consumption of an individual landowner	Consumption	*c*
Price of consumption goods	Price	P_c
Choice of land use	Land Use	*LU*
Subscript to denote from land source	Land subscript	*land*
Subscript to denote from other (non-land) source	Other subscript	*other*
Subscript to denote base case without any land use change into bioenergy crops	Base subscript	*0*
Subscript to denote land use change into bioenergy crops	Land change subscript	*1*

Following the landowner utility maximization models of Binkley (1981) and Timmons (2011), utility is a function of consumption (*c*) and amenities (*a*):

$$max_{LU}\ U = U\ [\ a, c\ ] \tag{1}$$

Utility is maximized over the land use decision and is constrained by income (*m*) and the availability of amenities, each of which can come from either land and other sources:

$$P_c * C\ <=\ m_{\text{land}} + m_{\text{other}} \tag{2}$$

$$a\ =\ a_{\text{land}} + a_{\text{other}} \tag{3}$$

Income from land and amenities from land are both functions of land use:

$$m_{\text{land}} = f(LU) \tag{4}$$

$$a_{\text{land}} = g(LU) \tag{5}$$

A change in land use results in a change in income from land and therefore consumption as well as a change in amenities from land:

$$\Delta LU \rightarrow \Delta m_{land} \rightarrow \Delta c \tag{6}$$

$$\Delta LU \rightarrow \Delta\, a_{land} \tag{7}$$

Changes in consumption and amenities affect utility and thus the decision to change land use can cause a net change in utility. Equation (8) shows the base case utility and equation (9) shows the utility after a change in land use (U_1).

$$U_0 = U\,[\,\mathrm{c}_0, a_0] \tag{8}$$

$$U_1 = U\,[\,\mathrm{c}_0 + \Delta c\,, a_0 + \Delta\, a] \tag{9}$$

If utility after the change is greater than utility in the base case, then the landowner will decide to change the land's use:

$$U_0 = U\,[\,\mathrm{c}_0, a_0] \;<\; U_1 = U\,[\,\mathrm{c}_0 + \Delta c\,, a_0 + \Delta\, a] \;\rightarrow\; \Delta LU \tag{10}$$

When this conceptual model is applied to the case of growing bioenergy crops on marginal land we can see that an individual landowner may or may not convert the land, depending on the amenities received from it. While growing the bioenergy crops may prove to be profitable on marginal land and thus raise the income of landowners, the extra consumption this allows landowners may not provide greater utility than the amenities the land provides them when it is not in use for bioenergy crops. In this case a utility maximizing landowner would not change their land's use even given their income would go up.

Chapter 5: Area Frame Sampling With GIS

In order to ask Michigan landowners about their willingness to supply marginal land through a survey, landowners had to be identified. However, not all landowners own marginal land, and there are even fewer who own significant amounts of it. Because no list of owners of marginal lands exists, this study uses an area frame sample built from GIS databases of non-crop marginal lands.

All parcels of marginal land in Michigan create a complete area frame for the entire population of research interest. Area frame sampling is the process of randomly selecting landowners whose ownership parcel intersects the area frame (Cotter and Nealon, 1987). One concern that often arises with area frame sampling is that larger parcels have a higher probability of selection and have the potential to distort the sample if owners of large parcels behave differently; however, this is not a concern in this study given that the objective is not to find how the typical land owner may behave but to find the potential supply of marginal land available for bioenergy crop production. This means that the natural effect of larger parcels of land being more likely to be sampled is actually ideal since decisions by these landowners have effects proportional to the amount of land they own on the potential supply of marginal land.

5.1 Geographic Database

For this study, area frame sampling followed a two-step procedure. First, an area frame consisting of all current marginal lands in Michigan had to be created. A recent land use database in Michigan, the Cropland Data Layer (CDL) of 2010, was used for this analysis.

CDL is a raster database that was created in 2010 by the United States Department of Agriculture (USDA) from satellite imagery using spectral reflectance data (National Agricultural Statistics Service, 2010). The database has 53 land cover categories with a crop-specific accuracy of 86.86% for each 30m pixel. The categories that were defined as marginal land are listed in Table 2.

Table 2. CDL 2010 - Classification of Land Use and Acreage in Southern Michigan

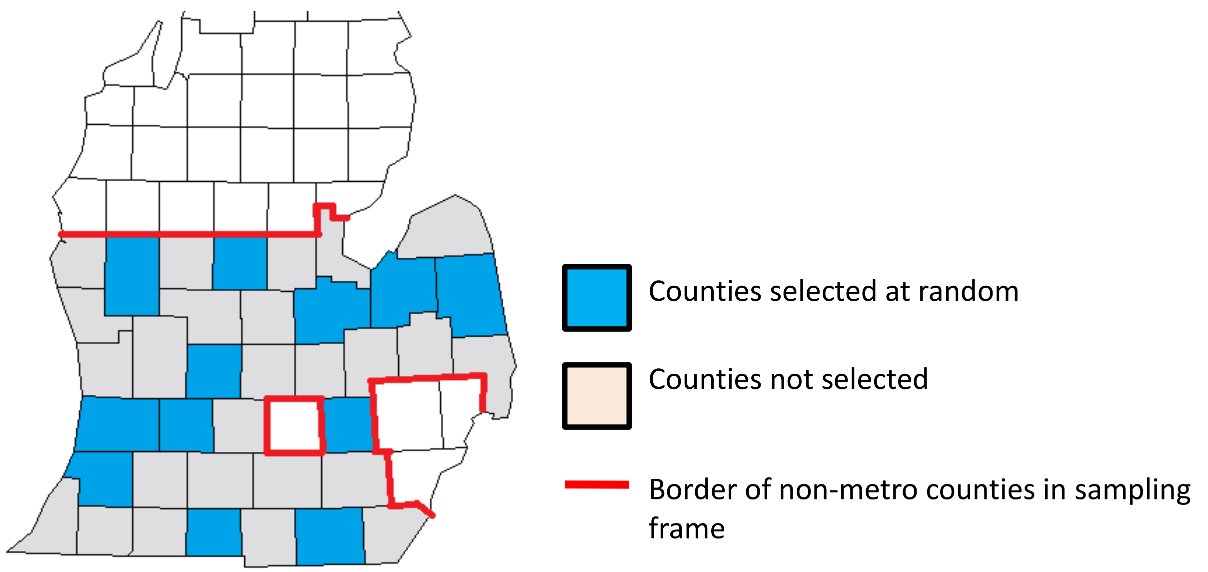
Land Use Classification	**Percent**	**Acres (mil.)**
Fallow / Idle Cropland	6%	0.17
Shrubland	4%	0.13
Grassland / Herbaceous	46%	1.4
Pasture / Hay	44%	1.3
Total	**100%**	**2.97**

5.2 Sampling Method

This study focused in the southern half of the Lower Peninsula, where most crop production occurs. Michigan counties south of the county of Clare, around 43.9 degrees latitude were considered.

In order to identify who owns land in Michigan, it was necessary to obtain county tax records; however, these records can be difficult to obtain. Not all counties in Michigan have digital records, and going through paper or pdf based maps is very time consuming. Also, many counties charge large fees for access to the data. Give this and the fact that this study had a limited budget, cluster sampling was done at the county level. Twelve counties in Michigan were randomly selected from those counties south of Clare. Allegan, Barry, Branch, Ionia, Isabella, Lenawee, Livingston, Newaygo, Saginaw, Sanilac, Tuscola, and Van Buren were selected. Figure 2 shows the randomly selected counties. The metropolitan counties of Detroit were excluded along with the county of Ingham, which was used for focus group pretesting of the survey questionnaire.

Figure 2. Randomly Selected Michigan Counties for Sampling



Ten acres was treated as the minimum viable land area for bioenergy crop production. Therefore, sampling began in each of the twelve selected counties by finding only parcels of marginal land greater than ten acres. Sampling was done from the CDL 2010. CDL 2010 is a database based on 30m pixels.

Figure 3. Example of Area Frame Selection

Sampling took place by randomly dropping points within the ten acre parcels of marginal land and then identifying, using county tax records, who owned the parcel of land in which the point fell. Points were limited in that they could not be dropped on the same parcel of marginal land within 300m of each other. This was done in order to maximize the probability of getting a different potential respondent and the probability of getting respondents with over ten acres of marginal land. In order to select areas of land over ten acres only contiguous parcels of 45 pixels or more of marginal land were considered. Figure 3 is an example of a parcel of marginal land greater than ten acres. The section of speckled pixels is all marginal land (the section is over 45 pixels or ten acres therefore it was considered for the survey). The second picture shows the actual property lines and where that point fell. The outline is then the piece of property whose owner was contacted for the survey.

The survey was targeted to 100 individuals in each of the randomly selected counties for 1200 individuals in total. However, not all of the counties selected had 100 different individuals with parcels of over ten acres of potentially marginal land in the CDL 2010 database. After dropping repeat individuals, individuals who owned parcels less than ten acres in size, and parcels owned by the public and corporate sectors, the following counties had less than 100 potential respondents: Saginaw – 95, Livingston – 84, and Branch – 73. This resulted in the survey being sent to a total of 1152 potential respondents.

Chapter 6: Survey Design

A mail survey was used to elicit these landowners' willingness to supply land for bioenergy crops. Currently, there is no market for cellulosic biomass; therefore, landowner decisions cannot be directly observed to determine value. Champ et al (2003) show how it is possible to value goods where a direct market does not exist for them by using a contingent valuation survey to elicit stated preferences where observed preferences do not exist. Often contingent valuation surveys are used to elicit a person's willingness to pay for a good, service, or amenity that does not have a market; however, contingent valuation surveys can be used to elicit willingness to accept payment to supply a good or service that currently is not sold. Swinton et al (2007) describe how it is possible to use contingent valuation surveys to elicit farmers' willingness to supply ecosystem services.

Throughout the survey design process many decisions were made in order to ensure that the survey completed its goal of eliciting Michigan landowners' willingness to supply their marginal land for bioenergy production. The first decision was to use a mail survey. A mail survey was preferred over an internet based or phone survey for three reasons. First, the recipient information was gathered from county tax records which included mailing addresses. Second, given that many landowners are older and live in more rural communities, their access to the internet may be limited. Third, mail surveys offer an advantage over phone based surveys in their ability to display visual information.

6.1 Questionnaire Format

The survey followed the tailored design method by Dillman (2009) with detailed question design and a series of mail outs with a one dollar incentive to elicit the highest response. The first part of the survey focused on landowners' current land management and land uses. They were asked to describe their land, whether they currently rented any of it, whether they used it for any non-agricultural uses, and what their attitude was towards renting their land. The goal of this section was to elicit how these landowners use their land.

The second section was a series of questions aimed to educate the respondents indirectly about bioenergy and bioenergy crops. Dillman (2009) discussed difficulties with getting respondents to read sections of text before answering questions but noted that they do read each question as they answer it. This section asked respondents if they were aware of certain features of bioenergy crops. The goal of this section was to allow respondents to more fully understand the decisions they were asked to make in the following contingent valuation section.

The part of the questionnaire after the contingent valuation question section was about respondents' attitudes towards the environment and what concerns they might have with renting their land. This section followed the contingent valuation question section in order to minimize bias to the contingent valuation questions. The goal of this section was to create attitudinal variables from which to see if environmentalism or certain concerns increase or decrease the probability of renting land for bioenergy crops.

The final section of the questionnaire elicited demographic information about respondents. This section was aimed at helping describe respondents and creating variables to see if demographic background plays an important role in landowner decisions.

6.2 Contingent Valuation Question

Figure 4 shows an example of the main contingent valuation question asked in each survey. This question aimed to elicit respondents' willingness to supply their land for bioenergy crops. This question starts out with an information section at the top that provides the respondent with unbiased background information on the crop so that they can make an informed decision. The contingent valuation question is framed as their willingness to rent their land to grow bioenergy crops. This format was used for two main reasons. First, many rural landowners in Michigan are not involved in farming at all; therefore, if the question was designed around them having to grow the crop themselves they would likely not be interested or not have the capabilities to do so. Second, a rental rate is a very easy payment method to understand. It does not involve calculating a series of costs and revenues related to farming to deduce a profit. The only cost is their land and the only revenue is rental rate times the amount of land they are willing to rent.

The actual decision question on supplying their land is structured as a simple binary choice. While a binary answer does not provide a lot of information there are inherent issues in using different question structures (Dillman 2009). An open ended question asking at what rental rate respondents would be willing to rent their land might lead people to overstate their actual value in an effort to affect potential future prices paid to them. In the same way when given multiple options of different rental rates to choose from respondents will often overstate their actual value or struggle from what is called median bias where a respondent believes the middle number provided to be closest to what their land is worth and therefore select it without considering their own true value (Dillman 2009).

The binary choice was extended in a few ways in order to obtain as much information as possible about the respondent's decision. It was first extended to allow respondents to state at a given price how many acres they would be willing to make available. This was done so that the results could be used to go beyond eliciting how many people are willing to rent to being able to deduce how much land would actually be available. The second way the binary question was extended was to allow respondents to explain their "no" responses. The first option "I do not own any existing cropland" lets us know if they should even be put into the cropland model. The other "no" options tell us whether their decision not to rent was based upon the rental rate or on a more general disagreement with the idea of renting out their land for that crop. The final way the contingent valuation question was extended was to allow respondents to answer the question for each type of land they owned. Earlier in the survey respondents were asked to classify their land into cropland, hay and pasture land, and other farmable lands. This was done in an effort to separate out how much marginal land might truly be available for bioenergy crops compared to how much cropland might be available.

Figure 4. Example of Contingent Valuation Question

SWITCHGRASS

Planted:	Spring of the first year
Harvested:	Every fall after year 1 or 2
Fertilized:	Yearly
Average number of farmer visits:	3 per year
Maximum height:	4 to 6 feet
Production:	Bioenergy
Soil erosion:	Low compared to other bioenergy crops
Greenhouse gas emissions:	Average compared to other bioenergy crops
Water contamination:	Low compared to other bioenergy crops
Crop as a wildlife habitat:	Good compared to other bioenergy crops
Rental rate paid to you by farmer:	**$50 DOLLARS PER ACRE PER YEAR**
Length of contract:	**5 YEARS IN SWITCHGRASS**

C4. If somebody wanted to rent your existing cropland to grow switchgrass for $50 an acre per year for 5 years, would you rent any of it out?

☐ Yes, I would be willing to rent out ⇨ ______ ACRES

☐ No (Choose one explanation)

- ☐ I do not own any existing cropland.
- ☐ I would not rent any of this type of land for this use no matter how high the rent was.
- ☐ I would rent out this type of land for this use if the rent were higher.

C5. If somebody wanted to rent your existing hay and pasture land to grow switchgrass for $50 an acre per year for 5 years, would you rent any of it out?

☐ Yes, I would be willing to rent out ⇨ ______ ACRES

☐ No (Choose one explanation)

- ☐ I do not own any existing hay and pasture land.
- ☐ I would not rent any of this type of land for this use no matter how high the rent was.
- ☐ I would rent out this type of land for this use if the rent were higher.

C6. If somebody wanted to rent your existing farmable non-crop land to grow switchgrass for $50 an acre per year for 5 years, would you rent any of it out? (The renter would be responsible for clearing costs. You would get any timber sales.)

☐ Yes, I would be willing to rent out ⇨ ______ ACRES

☐ No (Choose one explanation)

- ☐ I do not own any existing farmable non-crop land.
- ☐ I would not rent any of this type of land for this use no matter how high the rent was.
- ☐ I would rent out this type of land for this use if the rent were higher.

6.3 Experimental Design

The experimental design describes how the treatment variables were structured across the 32 versions of the survey in order to elicit landowners' willingness to supply land for bioenergy production. The rental rate and the contract length for a given bioenergy crop were the design variables that varied from one questionnaire to another. The conceptual framework set up how consumption affects utility and that consumption is bound by an income constraint. Here we use the first variable in the experimental design to measure the amount of potential income change. The rental rate a landowner sees multiplied by the amount of land they would rent is their change in income. Contract length plays into the landowner utility model in a different way. Landowners receive utility from amenities that can come from their land. These amenities change with a land use change such as growing bioenergy crops. Given that the contract length determines the time period for this land use change we can see that it would directly affect amenity values as well as any other opportunity of locking the land use for the agreed upon length of contract. The goal of this section is to explain how the different levels of these variables were chosen and how these levels were put into the questionnaire to provide the best potential analysis of the results.

The range of values assigned to the rental rate that respondents saw was based upon recent rental rates in Michigan. The 2010 and 2011 *Michigan Land Values and Leasing Rates* publications by Wittenberg and Harsh from the Department of Agricultural, Food and Resource Economics at Michigan State University were consulted to provide an accurate view of current

Michigan rental rates. Rental rates for cropland in Michigan in 2011 vary based upon crop, tillage practices, and irrigation but in the Southern Lower Peninsula $111 per acre was the average rate for tiled cropland and $84 per acre was the average rate for non-tiled cropland. Using these values as a reference points, respondents saw values of $50, $100, $200, or $300 as the rental rate per acre. At $50 per acre, the minimum rental rate offered was around half the typical rate. This rate was chosen because it is important to see how landowners respond to low rental rates that might be more realistic for bioenergy crops on lands of marginal production potential. In order to reach a level that would elicit a response from as many respondents as possible, the upper limit was three times the current average at $300 per acre. Respondents also saw the approximate average itself, $100 per acre, and double the average, $200 per acre, in order to provide greater information between the minimum and maximum rental rates offered.

The contract length varied between 5 and 10 years. The reason a varying contract length was provided to respondents was because many bioenergy crops are perennials and require time to grow before returning a consistent yield. Also, a land use change involving a longer commitment could have a different opportunity cost associated with it.

Given the levels of variation for rental rate and contract length, we now consider how to put them into the questionnaire in a way that results in the best potential analysis of the responses. First, we must remember that each cropping system has an independent stated choice question. That is, the cropping systems are not alternatives. The respondent is not deciding whether they will rent out their land for switchgrass or corn but rather given the listed price and contract length for switchgrass would they rent out their land to grow it. Since each cropping system is independent, the resultant combination of all possible levels across all factors, or full factorial design, for a given cropping system is quite small. Only two attributes vary, rental rate and contract length. Rental rate has only four levels and contract length has only two levels. This means that the full factorial design 4 x 2 = 8 combinations can easily be used for each crop. Using the full factorial design for each of the four bioenergy crops ensures orthogonality. Orthogonality means that each combination is uncorrelated, which results in each combination providing different information than the others. Orthogonal designs allow for independent estimation of the influence of each varying attribute, rental rate and contract length (Keppel and Wickens 2004). Thirty two versions of the survey were created by taking each crop and assigning it the eight full factorial combinations and then randomly pairing those combinations with other full factorial combinations for the three additional crops systems. This was done instead of using only eight versions of the survey to reduce potential bias created from the order of rental rates from only a few versions (Dillman 2009). Table 3 shows the 32 different versions used and highlights the eight full factorial design combinations in each cropping system. The other 24 combinations for each crop are simply the same eight combinations of the full factorial design repeated three more times but just randomly placed.

Table 3. Questionnaire Experimental Design

	Corn		Switchgrass		Hybrid Poplar		Mixed Prairie	
Survey Version	Rental Rate	Contract Length	Rental Rate	Contract Length	Rental Rate	Contract Length	Rental Rate	Contract Length
1	50	5	50	5	300	10	300	5
2	50	10	300	10	200	5	200	10
3	100	5	50	10	50	10	50	5
4	100	10	100	10	100	10	50	10
5	200	5	50	10	50	10	100	10
6	200	10	200	10	200	10	50	5
7	300	5	200	5	50	5	50	5
8	300	10	200	5	300	5	100	10
9	200	5	50	5	200	10	300	5
10	300	5	50	10	300	5	300	5
11	200	10	100	5	200	5	200	5
12	200	5	100	10	50	5	50	10
13	50	5	200	5	300	10	300	10
14	100	10	200	10	200	5	100	5
15	200	10	300	5	100	5	200	10
16	300	5	300	10	100	10	300	10
17	50	10	300	5	50	5	300	10
18	300	5	50	5	50	10	100	5
19	300	10	300	10	100	5	50	10
20	50	5	200	10	100	10	200	5
21	50	10	200	5	200	5	100	5
22	300	10	100	10	200	10	100	10
23	100	5	200	10	300	5	200	10
24	100	5	100	5	300	10	200	5
25	100	10	300	5	100	5	50	5
26	50	10	50	10	50	5	50	10
27	200	5	300	10	300	5	100	5
28	100	10	50	5	100	10	100	10
29	100	5	100	10	100	5	200	5
30	50	5	100	5	300	10	200	10
31	300	10	100	5	200	10	300	5
32	200	10	300	5	50	10	300	10

6.4 Questionnaire Review Process

The questionnaire went through multiple levels of review. First the survey design was presented on August 3, 2011 at the joint Michigan State University and University of Michigan Energy and Environmental Economics Day. After further survey development, on September 3, 2011 the questionnaire was sent out to nine experts in the fields of contingent valuation survey design, bioenergy, biology, agronomy, and crop and soil sciences. Then it was pretested during September 14-17, 2011 in face-to-face interviews with six landowners sampled from Ingham County in Michigan. After slight changes it was tested again with four more Ingham county landowners on September 27-28, 2011. The questionnaire was revised for clarity and to accommodate the fact that many rural landowners who were targeted for marginal land ownership also owned significant tracts of cropland. In November, 2011, the questionnaire was sent again to three professors in the field of agricultural, food, resource, and energy economics for comments. Then in December, 2011 the questionnaire was further field tested with five interviews in Allegan County in Michigan. Finally, the whole survey design was then presented on February 13-14, 2012 at Great Lakes Bioenergy Research Center (GLBRC) retreat where professors from MSU and University of Wisconsin (UW) in the fields of biology, biochemistry, agronomy, crop and soil sciences, and chemical engineering reviewed the design. This iterative process of testing and revision lead to a well refined questionnaire.

6.5 Survey Response Rate and Data Entry Methods

The first mail-out was sent on March 30, 2012. It was a letter informing potential respondents that in a few days they would be receiving an important survey for which their responses were highly valued. On April 6, 2012 questionnaire packets were sent out to the sample of 1152 owners of marginal land in the southern lower peninsula of Michigan. These packets included a cover letter introducing the questionnaire, the questionnaire itself, a one dollar bill as incentive, and a prepaid return envelope for the questionnaire. A reminder postcard was sent on the 17th of April, which urged recipients to respond if they had not yet. Lastly, a second questionnaire packet was mailed out on April 27, 2012 to those who did not respond to the first survey wave. This packet included a different cover letter and no incentive. Examples of all of these mail outs can be seen in an appendix. By August 6, 2012, three months after the first questionnaire wave, a total of 599 responses were collected. An additional 124 questionnaires were returned to sender by the Postal Service due to moved individuals, deceased individuals, and address errors. This resulted in the effective response rate for the survey being 58.3%.

Each questionnaire was coded and the data entered separately by two different individuals using the same coding system. When differences were found between the two coding versions, the original questionnaire was reexamined to correct any errors in coding. Cleaning of the data also took place to ensure that responses were within the limits of the question. All binary questions were limited to 0 and 1 and Likert scale questions were limited to 1, 2, 3, 4, and 5. Open ended integer questions were limited to positive numeric values. Very few responses fell outside the boundaries of the questions and those that did were coded as missing unless confirmed by both reviewers to be a clear alternative choice.

Michigan State University's Institutional Review Board (IRB) found the survey to be exempt from further review after the initial proposal. Nonetheless, to protect respondent confidentiality, safety steps were put in place. To begin, the returned questionnaires contained no personal contact information. Instead, a number system was used to link each questionnaire to a respondent identity database spreadsheet that was kept only on two MSU computers that were password protected and in a locked MSU office. While the questionnaire data was being entered, the questionnaires were stored in this same locked MSU office and not removed until after all data was entered. They were then moved into locked file cabinets to be stored in case of need for future reference for three years. At the end of this time they will be shredded and recycled.

Chapter 7: Empirical Methods

Through the questionnaire, landowners were asked to make two decisions for each bioenergy crop on each type of land that they own. First, landowners were asked whether they would be willing to rent any of their land to grow bioenergy crops. Second, if they said yes, they were asked how much of it they would be willing to rent. To analyze this two-step decision making process, an econometric hurdle model was used. Hurdle models allow the two decisions to be modeled separately with the understanding that different factors may affect these decisions.

The hurdle model was developed by Cragg in 1971 and has been used in a variety of contingent valuation studies. The hurdle model has been used in contingent valuation studies by Goodwin et al. (1993) to analyze hunters' willingness to pay, Reiser and Scechter (1999) to examine willingness to pay for environmental program benefits, Yu and Abler (2010) to infer willingness to pay for air pollution reduction in Beijing, and Jolejole (2009), to estimate farmers' willingness to supply ecosystem services. The hurdle model has also been widely used outside of the willingness to accept or supply studies in areas such as household food expenditures, consumption models, and demand for health care (Newman 2001, Jensen and Yen 1996, Yen and Jones 1997, and Pohlmeier and Ulrich 1995).

The hurdle model separates the decision to participate from the level of participation. In this study that means the decision to rent out land to grow bioenergy crops, referred to as the participation decision, is modeled separately from the decision of how many acres to commit, referred to as the acreage commitment model. Separating the two models allows the explanatory variables to have different coefficient estimates between the two models. From a theoretical standpoint this method is supported by the nature of the decisions and the explanatory variables used. For example the amount of total cropland a landowner owns may not have a significant effect on whether or not they will rent any cropland, but it may have a very significant effect on how much cropland they choose to rent out.

For a model with a dependent variable censored at zero, a tobit model may suffice if explanatory variable effects do not differ between the participation and commitment decisions. Therefore, a tobit model was also tested for modeling these landowner decisions. However, the likelihood ratio test comparing the tobit model with the hurdle model showed that the hurdle model offered a significant improvement in model fit. The results of this analysis can be seen at the end of the chapter in Table 10.

To model the participation and acreage commitment models, a probit and truncated regression are used. A probit model is used to estimate the binary response of whether the landowner is willing to rent land for bioenergy crops. It is estimated using standard maximum likelihood procedure and takes the basic form below in Equation (11), where Y is the binary choice of whether to rent, Pr denotes probability, Φ is the normal cumulative distribution function, X is a vector of explanatory variables, β_p is a vector of parameters and σ_p is the standard deviation for the participation model estimated by maximum likelihood, and the subscript i denotes an individual landowner. This framework for the hurdle is adapted from Jolejole (2009).

$$\Pr(Y_i = 1 \mid X_i) = \Phi(\frac{\beta_p X_i'}{\sigma_p}) \tag{11}$$

A truncated regression is used to model the second step of the hurdle, the acreage commitment model. This model takes the simple form seen in Equation (12), where A is acres rented, β_a the vector of coefficients, X the explanatory variables, and ε_{ai} the independently and normally distributed error term with mean zero and variance σ_a^p

$$A_i = \beta_a X_i' + \varepsilon_{ai} \tag{12}$$

Enrolled acres are only observed if $A_i > 0$ so our expected value of acres is,

$$E(A_i|A_i > 0) = \beta_a X_i' + \sigma\lambda(\gamma) \tag{13}$$

where

$$\lambda(\gamma) = \frac{\phi(\gamma)}{1-\Phi(\gamma)} \quad \text{and} \quad \gamma = \frac{-x\beta_a}{\sigma} \tag{14}$$

where $\phi(.)$ is the standard normal probability density function and $\Phi(.)$ is the standard normal cumulative distribution function.

The hurdle model allows for the coefficients from the participation and acreage commitment models to be different as seen in how they are labeled with different subscripts to denote that they are from either the participation model or the acreage commitment model.

These two models can then be combined to show that how many acres would be expected of an individual landowner as displayed in Equations 13 and 14.

7.1 Variable Specification

The dependent binary variable in the probit participation model indicated whether or not a landowner was willing to rent a given type of land. If they were willing, the variable was set to 1; if they were not willing, it was set to 0. The dependent variable in acreage commitment model was a continuous variable simply equal to the number of acres that the individual was willing to rent.

The explanatory variables were split into five broad categories: current land management, income and amenity land uses, landowner opinions on the environment and renting concerns, landowner demographic information, and the terms of the rental agreement. A complete list of all the variables used in each category can be seen in Table 4.

Current land management practices were variables that described what the landowner's land looked like in terms of division between cropland, pasture, and other land covers. Income and amenity based land uses were binary choice variables that landowners could select. The landowner demographic variables provided a basic description in terms of age, gender, income, and job of the landowner responding to the survey. The final set of explanatory variables included the experimental design variables that described the rental scenario to the landowner in terms of rental rate and contract length. Some variables that were created from the questionnaire responses were dropped due to multicollinearity detected through F-tests; other variables were dropped by testing for simultaneous statistical insignificance through Wald test.

Table 4. Variable Specification for Variables Used in Analysis

Dependent Variables	Description	Units
Decision to Rent Out Land	Whether to rent cropland, pasture, and/or other land for corn, switchgrass, prairie, and/or poplar	Binary (yes/no)
Number of Acres Rented	Number of acres rented of cropland, pasture, and/or other land for corn, switchgrass, prairie, and/or poplar	Acres
Explanatory Variables		
Current Land Management		
Currently Rents Land	Whether the landowner currently rents land	Binary (yes/no)
Total Cropland Owned	Total amount of cropland the landowner owns	Acres
Total Pasture Owned	Total amount of pasture/hay the landowner owns	Acres
Total Other Land Owned	Total amount of other land the landowner owns	Acres
Total CRP Land Owned	Total amount of land committed into CRP	Acres
Income and Amenity Land Uses		
Combined Amenity – Based Uses	Number of uses for the land: scenery, physical activities, recreational vehicle use, and as a home	0, 1, 2, 3, 4
Combined Hunting – Related Uses	Number of uses for the land: hunting and fishing and food plots for game	0, 1, 2
Grazing	If their land is used for grazing	Binary (yes/no)
Commercial Income	If their land is used for commercial income	Binary (yes/no)
Conservation Income	If their land is used for conservation income	Binary (yes/no)
Landowner Opinions on the Environment and Renting Concerns		
Environmental Factor – Renewable Energy	Factor variable based upon Likert scale variables related to opinions on renewable energy	Factor*
Environmental Factor – General Environmentalism	Factor variable based upon Likert scale variables related to opinions on general environmentalism	Factor*
Concerns factor – Agricultural Production	Factor variable based upon Likert scale variables related to concerns with agricultural production	Factor*
Concerns factor – Renting Land to Farmer	Factor variable based upon Likert scale variables related to concerns with renting land to a farmer	Factor*
Landowner Demographic Information		
Age	Landowner's age	Age in Years
Male	Whether the landowner's gender is male	Binary (yes/no)
Farmer	Whether or not the landowner is a farmer by trade	Binary (yes/no)
Income	What level of income the landowner falls into 12.5k, 37.5k, 75k, 125k, 175k, 300k	
Terms of Rental Agreement		
Rental Rate	The rental rate per acre per year offered for a given crop	$50, $100, $200, $300
Contract Length	The contract length offered for a given crop	5, 10 (years)

A complete view of the variables and their levels can be seen in the Mail Outs and Questionnaire section
*Factors come from factor analysis as described 7.2

7.2 Factor Analysis

The sections on landowners' opinions on the environment and concerns related to renting created a series of variables based on responses to Likert scale questions. Many of these variables were highly correlated with one another. This led us to question whether the variation in these variables was really just a reflection of variation in a smaller number of unobserved variables. Factor analysis allows for the creation of new variables, based upon linear combinations of observed variables, that best reflects the variation of the underlining unobserved variable. By creating these new variables the total number of variables in the dataset could be reduced adding greater degrees of freedom and a reduction in highly correlated variables.

Tables 5-7 show the results of the factor analysis. Among both the environmental attitudinal variables and the landowner concerns, only the first two factors are kept because they showed eigenvalues over one (Table 5). We can also see that the first two factors explain 63% and 64% of the variation for the environmental and concern related variables, respectively. The factors were then rotated according to a varimax rotation to ensure orthogonal factors that are not correlated. In Tables 6 and 7, shading denotes the dominant variables in the first factor for the environmental and concern related rotated factors. The column uniqueness in the factor analysis displays the variance that is unique to the variable and not shared with any others.

Table 5. Factor Analysis for Environmental Attitudes and Landowner Concerns

Environmental Attitudes			Landowner Concerns		
Factor	**Eigenvalue**	**Cumulative Explained Variance**	**Factor**	**Eigenvalue**	**Cumulative Explained Variance**
Factor1	3.2047	0.4578	Factor1	4.4522	0.4947
Factor2	1.2128	0.6311	Factor2	1.2940	0.6385
Factor3	0.8031	0.7458	Factor3	0.9177	0.7405
Factor4	0.6140	0.8336	Factor4	0.6492	0.8126
Factor5	0.5207	0.9079	Factor5	0.4546	0.8631
Factor6	0.3548	0.9586	Factor6	0.4050	0.9081
Factor7	0.2895	1	Factor7	0.2991	0.9414
			Factor8	0.2849	0.973
			Factor9	0.2428	1

Table 6. Varimax Rotated Factors for Environmental Attitudes

Observed Variable	Factor1	Factor2	Uniqueness
Growing crops for auto fuel is necessary	0.8681	-0.0595	0.2428
Burning renewables is worth it over coal	0.8469	-0.1565	0.2583
Humans have the right to modify the environment	0.255	0.7297	0.4026
Humankind is severely abusing the environ	0.4614	-0.671	0.3369
This ecological crisis has been exaggerated	-0.4189	0.6268	0.4316
The balance of nature is easily upset	0.328	-0.6581	0.4594
Renewable energy is not urgently needed	-0.7077	0.22	0.4507

*Highlighted variables are those contributing mostly to Factor1 or 2, respectively.

Table 7. Varimax Rotated Factors for Landowner Concerns

Observed Variable	Factor1	Factor2	Uniqueness
Smell	0.1199	0.8641	0.239
Noise	0.2236	0.8539	0.2208
Dust in air	0.2333	0.8638	0.1993
Potential legal costs	0.6195	0.4702	0.3952
Length of contract	0.7658	0.196	0.3752
Possible need for insurance	0.778	0.2216	0.3456
Having others on my land	0.7709	0.2644	0.3358
Land use changing so I can no longer use it	0.6902	0.1211	0.5089
Use of pesticide and fertilizer	0.4786	0.3702	0.6339

*Highlighted variables are those contributing mostly to Factor1 or 2, respectively.

The use of factor analysis is further supported here by the clear grouping of related variables. The variables that make up the first environmental attitude factor all address renewable energy , while the variables that make up the second environmental attitude factor all relate to a more general environmental position as determined by the social psychology group "The New Environmental Paradigm" (Dunlap 2008). The variables that construct the first landowner concern factor all relate to sensory effects of agricultural production and the variables that construct the second landowner concern factor all relate to the renting of land.

7.3 Weighting and Scaling Model to Southern Lower Michigan

In order to permit extrapolation from survey respondents to the population of the region as a whole (scaling up), the observations were weighted according to the probability that an observation was included given the sampling design. In this study, we sampled owners of ten acres or more of marginal land from 12 counties; however, not all counties had the same number of ten acre plus tracts of land. Table 8 shows the number of ten acre plus tracts of marginal land that exist in each county according to the GIS analysis discussed in Chapter 5. Next it shows the number of observations from each of those counties that were observed. The probability that an observation was included given the sampling design can be seen in the next column, which was created by dividing the number of responses for each county by the number of ten acres plus marginal land tracts in that county. The final column simply shows the inverse probability weights (pweights), the weights used in the analysis or inverse of the probability in the column before. The pweights allow counties that were under sampled according to their number of tracts of ten acres or more of marginal land to have a greater impact on the model.

For example Livingston county has the largest number of tracts of marginal land that are ten acres or more, 1,210 tracts, but the second lowest number of responses, 30 responses, thus Livingston is given the largest pweight of 40.33.

Table 8. Design for Weighting Observations

County	Number of Ten Acres or More Marginal Land Tracts	Number of Responses for the County	Probability that an Observation was Included Given the Sampling Design	pweights (Inverse of Probability)
Allegan	1028	42	0.04	24.48
Barry	486	44	0.09	11.05
Branch	67	26	0.39	2.58
Ionia	316	45	0.14	7.02
Isabella	620	42	0.07	14.76
Lenawee	970	48	0.05	20.21
Livingston	1210	30	0.02	40.33
Newaygo	862	46	0.05	18.74
Saginaw	558	42	0.08	13.29
Sanilac	923	36	0.04	25.64
Tuscola	952	51	0.05	18.67
Van Buren	743	46	0.06	16.15

Creating a supply curve for all of southern Lower Michigan involved scaling up what we knew about our survey respondents. Combining the probit, participation model, and the truncated, acreage commitment model, told us how many acres of marginal land an average southern Lower Michigan landowner who owns at least ten acres of marginal land is willing to rent. To scale up, we need to know how many tracts of at least ten acres of marginal land exist in Southern Lower Michigan. The GIS analysis in Chapter 5 showed that 2.85 million acres of marginal land exist in southern Lower Michigan; however, much of that land is in areas less than ten acres. Of our 12 counties that we sampled from only 21% of the acres of marginal land were in tracts of at least ten acres and these tracts averaged 23 acres in size. Twenty one percent of 2.85 million is about 600 thousand acres. Dividing these 600 thousand acres by an average tract size of 23 acres gives us a total of 26 thousand tracts of least ten acres existing in Southern Lower Michigan. This number was then multiplied by the willingness to supply marginal land of our average respondent to provide us with an estimation of the willingness to supply of all of Southern Lower Michigan. Table 9 shows these calculations and steps.

Table 9. Calculations for Scaling up to Southern Lower Michigan

Total Number of Acres of Marginal Land in Southern Lower Michigan	2.97 Million Acres
Percent of Marginal Land in Tracts of at Least Ten Acres	21%
Total Number of Acres of Marginal Land in at Least Ten Acre Tracts in Southern Lower Michigan	600,000 Acres
Average Size of a Tract of Marginal Land that is at Least Ten Acres	23 Acres
Estimated Number of Tracts of Marginal land that are at Least Ten Acres in Southern Lower Michigan	26,000 Acres

Table 10. Likelihood Ratio Test Comparing Tobit vs. Hurdle Model

	Prairie	Poplar	Switchgrass	Corn
Cropland				
Chi Squared	3312	2820	2871	5027
Prob. Chi Squared	0.00	0.00	0.00	0.00
Pasture				
Chi Squared	4376	3647	4808	4000
Prob. Chi Squared	0.00	0.00	0.00	0.00
Other Marginal Land				
Chi Squared	4734	3344	4603	3150
Prob. Chi Squared	0.00	0.00	0.00	0.00

Chapter 8: Hypotheses

The purpose of this research project is to examine the availability of marginal land for bioenergy crops in Michigan and how landowners make the decision to change their land's use. To address these goals we developed a series of hypotheses to help us answer the relevant questions. These hypotheses are stated here with the theoretical rationale for their existence. In the results section each hypothesis is examined based upon the regression results, general survey responses, and statistical tests.

1a. As rental rates increase, the probability of renting will increase

1b. As rental rates increase, the level of acreage committed will increase

An increase in rental rate is expected to increase the probability of renting and the amount of land a landowner is willing to rent. Based on the conceptual model designed in Chapter 4, landowners desire to maximize utility. As rental rate increases, the utility received from consumption through income will rise. The larger the change in utility from income, the greater the probability that the change will offset any utility loss that the land may have provided in the form of amenities.

2. The contract length offered will influence landowner decisions.

Depending on landowner preferences, either a five year or a ten year contract might be preferable. Some landowners might have future plans for their land or expect land rent prices to go up in the future and therefore prefer a shorter five year contract. On the other hand, some landowners might perceive that the rental rate they were offered was high and prefer to get that guaranteed rental rate for as long as possible.

3. Many landowners will not rent their land even at extremely high rental rates.

It is expected that for some landowners an increase in income from their land over a plausible range will not elicit a change in their land use. Some individuals do not like the idea of bioenergy, others do not want anyone growing crops on their land except themselves, others do not want crops at all, and still others are simply comfortable with their current income and see any change as an effort not worth pursuing. Our conceptual model focuses heavily on the idea that “rational” individuals seek utility maximization and that utility need not come only through consumption of goods and services purchased through income but also from amenities, amenities that can be tied to land. Therefore, a “rational” utility maximizing landowner may decide not to rent for bioenergy crops even at a high rental rate because they receive a very large amount of utility through amenities by leaving the land the way it is.

4. At the same rental rate, landowners will have a higher probability of renting out land to grow mixed prairie or switchgrass crops rather than poplar trees or corn.

Mixed prairie and switchgrass are crops that benefit from being perennials. For this reason, they require fewer inputs and less management. Having fewer inputs is a benefit in the sense of input costs and because many inputs such as fertilizer and pesticide can lead to environmental costs. Reduced land management is a benefit because it decreases the costs associated with growing the crop. Hybrid poplar trees are also perennials and offer these same benefits; however, they have a much larger presence on a piece of land and have a root system that would involve extensive work and cost to remove if the land were ever to change use in the future. Corn is not a perennial and of all the crops in this study it requires the most agrochemical inputs and the highest level of management. Switchgrass and prairie also involve less relative production noise and disturbance. Therefore, at the same rental rate it is expected that mixed prairie and switchgrass would be the preferred crops.

5. At the same rental rate, landowners will rent out marginal land over cropland.

All land uses have opportunity costs. Cropland has the opportunity cost of utility from consumption through income that the land generates to the landowner either in the form of a rental rate or from selling the products of farming it. Cropland also has the opportunity cost of amenities that the landowner receives from it, even given that these amenity values may be relatively smaller. Marginal land that is not in crops often provides no income to the landowner and therefore no monetary opportunity cost exists. However, both cropland and marginal land have opportunity costs that come from amenities. These opportunity costs are harder to measure and could range from no longer being able to hunt on the land to a change in the desired scenery. The question then becomes when a landowner is offered the same rental rate to grow energy crops on cropland versus marginal land, will the opportunity costs from income and amenities on existing cropland be greater than or less than the opportunity costs from amenities on marginal land? To answer this, we must ask why is the marginal land currently not in agricultural production? If it is not in production because it will not produce crops profitably, then it is likely that the opportunity cost of the marginal land is less than that of the cropland. However, if the land is marginal because it offers greater amenities that provide the landowner with enough utility to offset the potential utility gain from consumption due to greater income from growing crops, then it is likely that the opportunity cost of the marginal land relative to its potential production income is greater than that of the cropland. While both of these reasons for marginal land are possible, evidence from landowner interviews has shown that marginal land lays idle more often because of amenities received from it rather than a complete lack of potential profit. Much of the idle land has characteristics that make it less desirable for growing crops, characteristics that range from higher irrigation costs to sandier, less fertile soil. Thus, in most cases cropland would have higher opportunity costs associated with converting it to bioenergy crops than marginal land, meaning that landowners will prefer to rent marginal land, given the same rental rate.

6. Most landowners who own marginal land will own cropland as well.

Rural landowners who own marginal land often own cropland. This hypothesis emerged from our qualitative interviews with landowners and our review of geographical databases.

Many owners of marginal lands also told us about their cropland. When observing tracts of marginal land in geographic databases overlaid with property parcel boundaries, it became very apparent that parcel boundaries that included marginal land rarely were covered completely by it. In most cases, the parcel boundaries included tracts of cropland that constituted a larger portion of the parcel than the marginal land tracts did. These two observations gave clear reason to expect that individuals who own marginal land also own cropland.

7. At the same rental rate, landowners who own more land will have a higher probability of renting.

Owners of large areas of land have more land that may vary in opportunity cost to the point where growing bioenergy crops at a given rental rate provides a benefit to them greater than the opportunity cost on at least some part of their varying land. Also most owners of large land areas use it as a source of income. This means that they are either familiar with renting their land to grow crops or else they farm the land themselves. In both cases, they are more likely to gain utility from the land via income generation than from amenities. So if their opportunity cost for the land arises mostly from income, they would have a lower opportunity cost for the land than a smaller landowner who receives utility from amenities of the land. Given that large landowners have land of more heterogeneous quality and they also get lower marginal utility from land amenities, they will be more likely to rent their land than a small landowner at the same rental rate.

Chapter 9: Results

9.1 The Participation Model Results

The participation decision was modeled for each bioenergy crop on each land type. The results of the probit models for the four different bioenergy crops, mixed prairie, hybrid poplar trees, switchgrass, and corn, on the three different land types, cropland, pasture land, and other marginal lands, can be seen in Tables 11-13. These results include parameter estimates and standard errors for each explanatory variable. Across the twelve models only a few variables were consistently significant. The participation decision is most statistically influenced by four variables: the rental rate offered, whether the landowner currently rents any land, whether the landowner has certain preexisting land uses, and whether the landowner has certain concerns with renting.

The influence of the rental rate can be seen clearly. As the rental rate offered increased from $50 per acre to $300 per acre, more landowners were willing to participate in growing bioenergy crops on their land. This is illustrated in Tables 11-13 where the variable for rental rate is positive and significant in each model. This result answers Hypothesis 1a showing that rental rate has the expected effect of increasing landowner willingness to participate.

Table 11. Probit Participation Model for Cropland Rented for Prairie and Poplar

	Prairie	**(n=251)**	**Poplar**	**(n=252)**
	Coef.	Z-score	Coef.	Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.62	3.79***	0.81	4.93***
Contract length (yrs)	-0.09	-2.14**	-0.02	-0.54
Current Land Management:				
Currently Rents Land (0/1)	0.67	3.01***	0.35	1.39
Current Land Owned:				
Total Cropland (acres)	-0.00045	-1.17	0.00013	0.47
Total Pasture (acres)	0.00058	0.94	-0.00032	-0.36
Total Other Land (acres)	0.00005	0.04	-0.00042	-0.44
Total CRP Land (acres)	0.0040	1.67*	0.0021	0.99
Current Land Uses:				
Group of Non-Land Based Uses	0.33	4.53***	0.24	2.62***
Group of Hunting Related Uses	0.07	0.44	0.09	0.52
Grazing Livestock (0/1)	-0.25	-0.95	-0.05	-0.20
Commercial Income (0/1)	-0.02	-0.08	0.45	1.68*
Conservation Income (0/1)	-0.29	-1.15	-0.36	-1.35
Environmental Factors:				
Renewable Energy	-0.08	-0.80	0.09	0.84
General Environmentalism	0.08	0.80	0.13	1.20
Concerns Factors:				
Agricultural Based	-0.02	-0.16	-0.07	-0.67
Renting Land Based	-0.07	-0.64	-0.28	-2.21**
Demographic Information:				
Age (yrs)	0.01	0.70	-0.01	-0.74
Male (0/1)	-0.07	-0.24	0.26	0.87
Farmer (0/1)	-0.17	-0.71	-0.56	-2.12**
Income (scale 1-6)	1.68E-06	1.20	-1.32E-06	-0.75
Constant	-4.34	-3.49***	-4.99	-4.04***
Log Likelihood Values	-1966.49		-1740.96	
Wald Chi-Squared	73.79		55.47	
Probability Chi-Squared	0.00		0.00	
Pseudo R-Squared	0.2613		0.237	

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

Table 12. Probit Participation Model for Cropland Rented for Switchgrass and Corn

	Switch grass Coef.	**(n=247)** Z-score	**Corn** Coef.	**(n=266)** Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.69	4.47***	0.93	4.35***
Contract length (yrs)	-0.02	-0.40	-0.04	-0.84
Current Land Management:				
Currently Rents Land (0/1)	0.87	3.85***	1.70	6.1***
Current Land Owned:				
Total Cropland (acres)	-0.00007	-0.22	0.00042	1.67*
Total Pasture (acres)	-0.00019	-0.22	0.0011	1.64
Total Other Land (acres)	0.00063	0.77	-0.0023	-1.53
Total CRP Land (acres)	-0.0023	-1.13	-0.00006	-0.03
Current Land Uses:				
Group of Non-Land Based Uses	0.27	3.55***	0.29	3.31***
Group of Hunting Related Uses	0.07	0.50	0.40	2.37**
Grazing Livestock (0/1)	-0.23	-0.99	0.01	0.04
Commercial Income (0/1)	0.05	0.20	-0.12	-0.47
Conservation Income (0/1)	-0.19	-0.82	-0.79	-3.05***
Environmental Factors:				
Renewable Energy	0.05	0.50	0.00	-0.02
General Environmentalism	0.06	0.56	0.07	0.75
Concerns Factors:				
Agricultural Based	-0.06	-0.60	-0.29	-2.26**
Renting Land Based	-0.12	-1.09	-0.24	-1.67*
Demographic Information:				
Age (yrs)	0.00	-0.03	0.00	0.52
Male (0/1)	-0.11	-0.40	0.03	0.11
Farmer (0/1)	0.09	0.43	0.23	0.96
Income (scale 1-6)	-2.44E-06	-1.82*	-1.90E-06	-1.39
Constant	-4.42	-4.01***	-6.80	-4.55***
Log Likelihood Values	-2156.46		-1716.92	
Wald Chi-Squared	55.84		74.90	
Probability Chi-Squared	0.00		0.00	
Pseudo R-Squared	0.2015		0.4064	

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

Table 13. Probit Participation Model for Pasture and Hay Land Rented for Prairie and Poplar

	Prairie	**(n=274)**	**Poplar**	**(n=274)**
	Coef.	Z-score	Coef.	Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.44	3.65***	0.48	3.33***
Contract length (yrs)	-0.05	-1.24	0.00	0.03
Current Land Management:				
Currently Rents Land (0/1)	0.20	0.99	0.09	0.42
Current Land Owned:				
Total Cropland (acres)	-0.0015	-1.89*	0.00000	0.01
Total Pasture (acres)	0.0012	1.28	0.00026	0.34
Total Other Land (acres)	-0.0015	-1.16	0.00009	0.08
Total CRP Land (acres)	0.0016	1.18	-0.0022	-1.15
Current Land Uses:				
Group of Non-Land Based Uses	0.09	1.17	0.05	0.56
Group of Hunting Related Uses	-0.02	-0.14	-0.11	-0.73
Grazing Livestock (0/1)	-0.16	-0.71	0.02	0.07
Commercial Income (0/1)	-0.23	-1.04	-0.37	-1.46
Conservation Income (0/1)	0.01	0.05	-0.30	-1.36
Environmental Factors:				
Renewable Energy	-0.03	-0.29	0.02	0.21
General Environmentalism	0.00	-0.06	0.13	1.31
Concerns Factors:				
Agricultural Based	-0.06	-0.64	-0.03	-0.32
Renting Land Based	0.02	0.23	-0.17	-1.54
Demographic Information:				
Age (yrs)	-0.01	-0.63	-0.01	-1.43
Male (0/1)	-0.13	-0.58	0.38	1.41
Farmer (0/1)	-0.40	-1.97**	-0.51	-2.38**
Income (scale 1-6)	2.91E-06	2.13**	-3.17E-07	-0.23
Constant	-1.76	-1.82*	-2.25	1.06
Log Likelihood Values	-2672.26		-2200.96	
Wald Chi-Squared	48.90		39.12	
Probability Chi-Squared	0.00		0.01	
Pseudo R-Squared	0.1462		0.1283	

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

Table 14. Probit Participation Model for Pasture and Hay Land Rented for Switchgrass and Corn

	Switch grass Coef.	**(n=268)** Z-score	**Corn** Coef.	**(n=275)** Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.57	3.9***	0.67	4.23***
Contract length (yrs)	-0.02	-0.43	0.03	0.70
Current Land Management:				
Currently Rents Land (0/1)	0.38	1.87*	0.70	3.04***
Current Land Owned:				
Total Cropland (acres)	-0.00021	-0.68	0.00005	0.16
Total Pasture (acres)	0.00045	0.65	0.0015	1.79*
Total Other Land (acres)	-0.00003	-0.02	-0.00045	-0.34
Total CRP Land (acres)	-0.0022	-1.41	-0.00016	-0.10
Current Land Uses:				
Group of Non-Land Based Uses	0.07	0.94	-0.01	-0.08
Group of Hunting Related Uses	-0.06	-0.41	0.15	1.12
Grazing Livestock (0/1)	-0.30	-1.37	-0.16	-0.71
Commercial Income (0/1)	-0.14	-0.61	-0.51	-2.21**
Conservation Income (0/1)	-0.11	-0.54	-0.63	-2.76***
Environmental Factors:				
Renewable Energy	0.09	0.93	0.08	0.89
General Environmentalism	0.09	1.10	0.24	2.69***
Concerns Factors:				
Agricultural Based	-0.09	-0.97	-0.13	-1.42
Renting Land Based	-0.03	-0.25	-0.15	-1.41
Demographic Information:				
Age (yrs)	0.00	-0.29	0.00	-0.03
Male (0/1)	-0.19	-0.82	0.33	1.26
Farmer (0/1)	-0.03	-0.15	0.01	0.05
Income (scale 1-6)	-4.58E-08	-0.04	-6.73E-07	-0.49
Constant	-2.73	-2.76***	-4.31	-4.06***
Log Likelihood Values	-2684.83		-2403.75	
Wald Chi-Squared	31.41		54.96	
Probability Chi-Squared	0.05		0.00	
Pseudo R-Squared	0.1046		0.1922	

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

Table 15. Probit Participation Model for Other Marginal Lands Rented for Prairie and Poplar

	Prairie	**(n=354)**	**Poplar**	**(n=349)**
	Coef.	Z-score	Coef.	Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.43	3.96***	0.66	5.51***
Contract length (yrs)	-0.02	-0.69	-0.03	-1.00
Current Land Management:				
Currently Rents Land (0/1)	-0.01	-0.04	-0.40	-2.14**
Current Land Owned:				
Total Cropland (acres)	-0.00036	-1.13	-0.00019	-0.78
Total Pasture (acres)	-0.00031	-0.49	-0.00044	-0.72
Total Other Land (acres)	0.0011	1.19	0.0017	1.72*
Total CRP Land (acres)	0.0015	0.96	-0.00052	-0.30
Current Land Uses:				
Group of Non-Land Based Uses	0.01	0.24	-0.01	-0.18
Group of Hunting Related Uses	0.15	1.31	0.00	-0.03
Grazing Livestock (0/1)	-0.12	-0.63	-0.27	-1.26
Commercial Income (0/1)	0.02	0.10	0.44	2.15**
Conservation Income (0/1)	-0.57	-2.86***	-0.15	-0.74
Environmental Factors:				
Renewable Energy	-0.05	-0.63	0.11	1.20
General Environmentalism	0.08	1.06	0.06	0.73
Concerns Factors:				
Agricultural Based	-0.12	-1.59	0.04	0.57
Renting Land Based	0.06	0.70	-0.20	-2.36**
Demographic Information:				
Age (yrs)	0.00	-0.13	-0.01	-1.50
Male (0/1)	-0.04	-0.19	0.30	1.43
Farmer (0/1)	0.02	0.13	-0.26	-1.45
Income (scale 1-6)	1.09E-06	0.90	8.67E-07	0.75
Constant	-2.20	-2.65***	-2.95	-3.39***
Log Likelihood Values	-3680.68		-3230.01	
Wald Chi-Squared	43.37		69.66	
Probability Chi-Squared	0.00		0.00	
Pseudo R-Squared	0.1076		0.1578	

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

Table 16. Probit Participation Model for Other Marginal Lands Rented for Switchgrass and Corn

	Switch grass	**(n=354)**	**Corn**	**(n=354)**
	Coef.	Z-score	Coef.	Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.28	2.34**	0.52	4.12***
Contract length (yrs)	0.02	0.63	0.07	2.02**
Current Land Management:				
Currently Rents Land (0/1)	-0.09	-0.48	0.05	0.24
Current Land Owned:				
Total Cropland (acres)	-0.00025	-0.79	0.00015	0.69
Total Pasture (acres)	-0.00094	-1.09	-0.00055	-0.05
Total Other Land (acres)	0.0023	2.32**	0.00084	0.82
Total CRP Land (acres)	-0.0035	-1.48	-0.0070	-1.52
Current Land Uses:				
Group of Non-Land Based Uses	0.06	0.90	-0.06	-0.94
Group of Hunting Related Uses	0.06	0.51	0.22	1.86*
Grazing Livestock (0/1)	-0.24	-1.15	-0.32	-1.57
Commercial Income (0/1)	0.19	0.95	-0.04	-0.22
Conservation Income (0/1)	-0.56	-2.69***	-0.60	-2.73***
Environmental Factors:				
Renewable Energy	0.06	0.77	0.09	1.07
General Environmentalism	0.04	0.46	0.24	2.97***
Concerns Factors:				
Agricultural Based	-0.04	-0.46	-0.16	-2.1**
Renting Land Based	-0.16	-1.88*	-0.14	-1.57
Demographic Information:				
Age (yrs)	0.00	-0.01	0.00	0.50
Male (0/1)	-0.30	-1.46	-0.07	-0.36
Farmer (0/1)	0.06	0.31	0.01	0.07
Income (scale 1-6)	-2.08E-07	-0.17	-3.68E-07	-0.28
Constant	-1.64	-2.03**	-3.68	-4.18***
Log Likelihood Values	-3716.60		-3171.77	
Wald Chi-Squared	39.63		58.97	
Probability Chi-Squared	0.01		0.00	
Pseudo R-Squared	0.0916		0.1669	

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

The second significant influential variable was that landowners who are currently renting out their land are more likely to participate in renting their land out for bioenergy crops as well. As expected, landowners who are accustomed to renting their land for an existing crop would likely not have any amenity change if the land use changed to growing a bioenergy crop. Also these individuals in general have shown a general preference to rent their land and that they are comfortable with letting others manage their land, not seeing it as unduly bothersome or a hassle.

The next consistently significant group of variables in most of the participation models were the variables related to uses for the land. Surprisingly, landowners who generally use their land for scenery, recreation, or physical activities are more likely to rent out their land for bioenergy crops. The interesting feature of this group of land uses is that none of them requires a specific land cover; they are all indirect land uses. On the other hand, landowners who use their land for conservation income are less likely to rent their land. This is consistent with our expectation that landowners who have alternative uses for their land that require a specific land cover will be less likely to participate in growing bioenergy crops.

The final two variable that are consistently significant in the participation model deal with concerns that a landowner might have when renting their land to grow bioenergy crops. As mentioned in the empirical methods section, a factor analysis of sources of concerns divided the concerns into two key types, those related to agricultural activities and those related to renting land in general. In both cases the greater these concerns the less likely the landowner is to participate in growing bioenergy crops.

One variable that was expected to be significant but was not was the contract length offered. Hypothesis 2 states, “The contract length offered will influence landowner decisions.” However, in 10 of the 12 participation models, estimated contract length was not significant even at the 10% level. Hence, we have no support for the hypothesis that contract length influences landowner decisions.

When the results of the participation decision are viewed graphically in Figures 5-7, three observations are apparent that correspond to different hypotheses. First, rarely are more than half of rural landowners willing to rent out any amount of land to grow bioenergy crops. This result obtains regardless of the bioenergy crop, the type of land the crop is being grown on, or the rental rate offered. At a typical crop rental rate of $100 per acre, the proportion willing to rent out for bioenergy crops falls to between 30 and 40 percent of rural landowners. This finding is consistent with Hypothesis 3, which states that even at high rental rates, many landowners will not be willing to rent out land for bioenergy crops. This finding is also consistent with the feedback from pretesting the survey with Michigan landowners. Many landowners simply were unwilling to rent their land for bioenergy crop production, regardless of the price offered.

The second observation is that on all three land types, landowners were most willing to rent out their land for switchgrass and prairie (Figures 5-7). This finding partially supports Hypothesis 4 that says, “At the same rental rate, landowners will have a higher probability of renting out land to grow mixed prairie or switchgrass crops over poplar trees or corn.” Landowners, particularly farmers, proved especially averse to renting land for hybrid poplar trees. They were less likely to rent out any type of land for hybrid poplar trees, with the exception of other marginal lands at high rental rates (when corn was the least preferred crop). Hybrid poplar trees may be less desirable because they have stumps and woody root systems that are difficult to remove if any potential future land use change is desired.

The third observation from Figures 5-7 is that landowners are only slightly more likely to rent out their marginal land than their cropland. If we look at just at prairie and switchgrass, the two bioenergy crops for which land is most likely to be rented, we see that the probability of renting cropland for is only 0.26 to 0.28 at a typical rental rate of $100 per acre, while at the same rate, the probability of renting pasture lands and other marginal lands is 0.32 to 0.38. These results offer weak support Hypothesis 5 that states, “At the same rental rate, landowners will rent out marginal land over cropland.”

Figure 5. Probability of Renting Cropland for Bioenergy Crops in Response to Rental Rate (Probit)

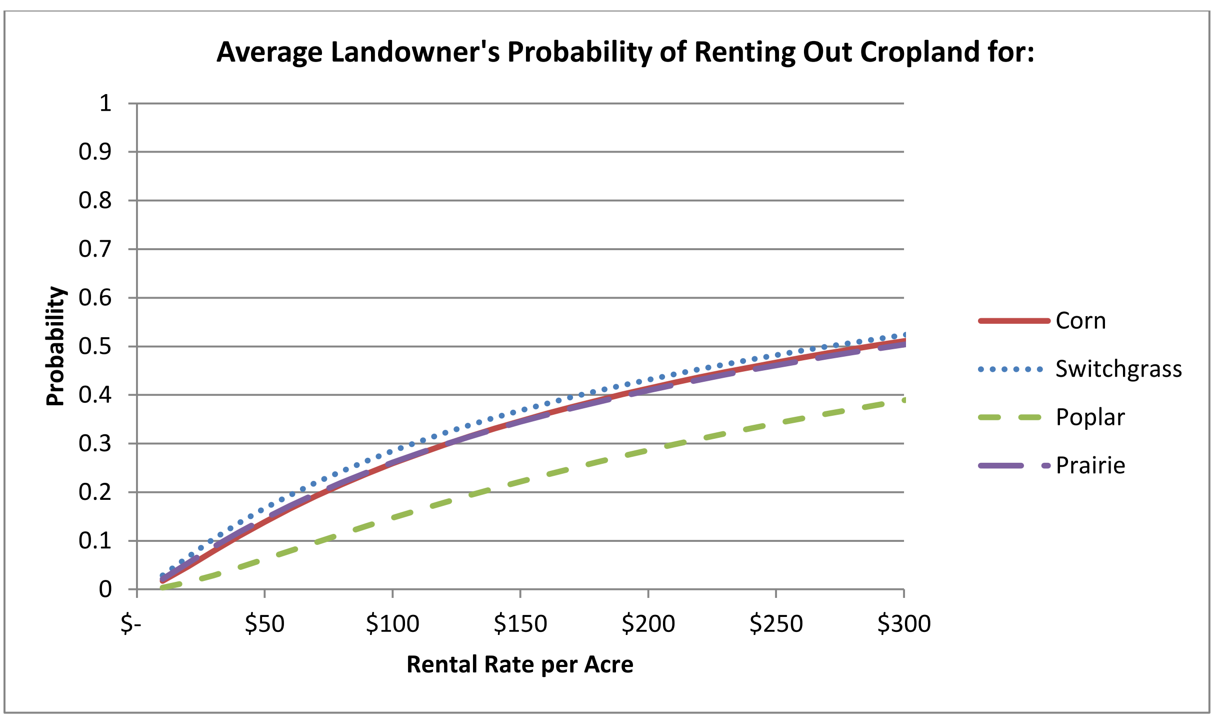


Figure 6. Probability of Renting Pasture Land for Bioenergy Crops in Response to Rental Rate (Probit)

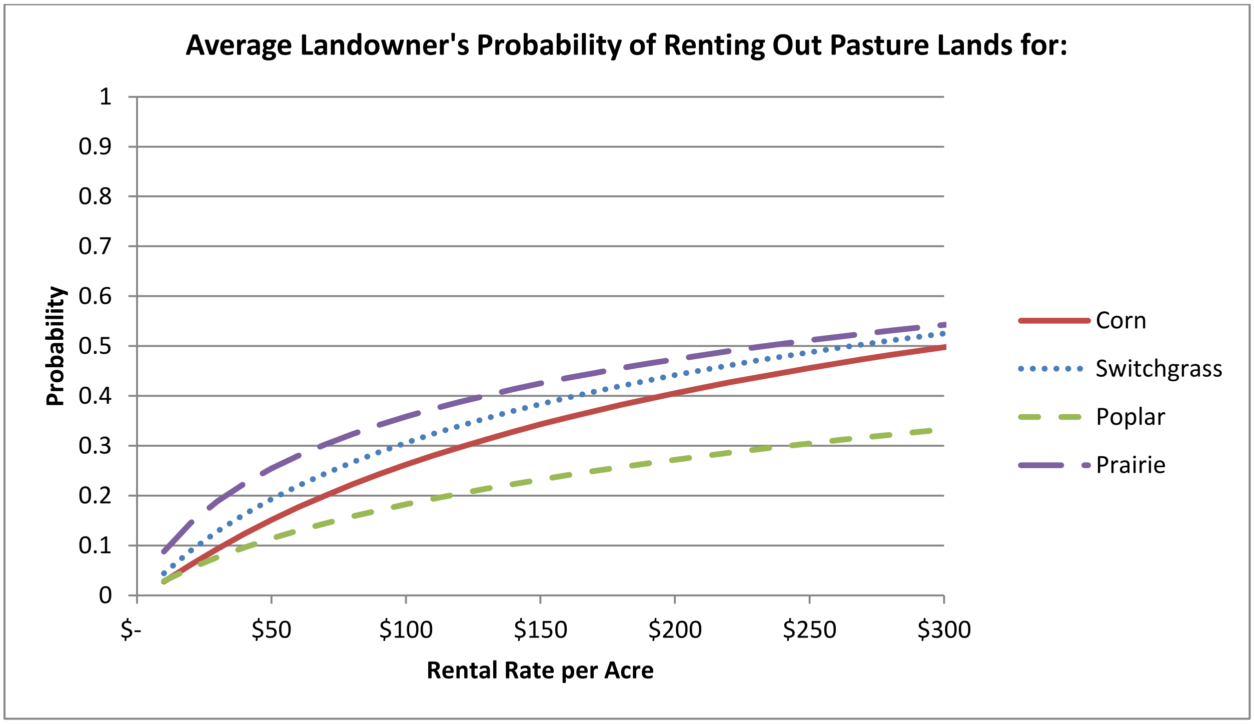
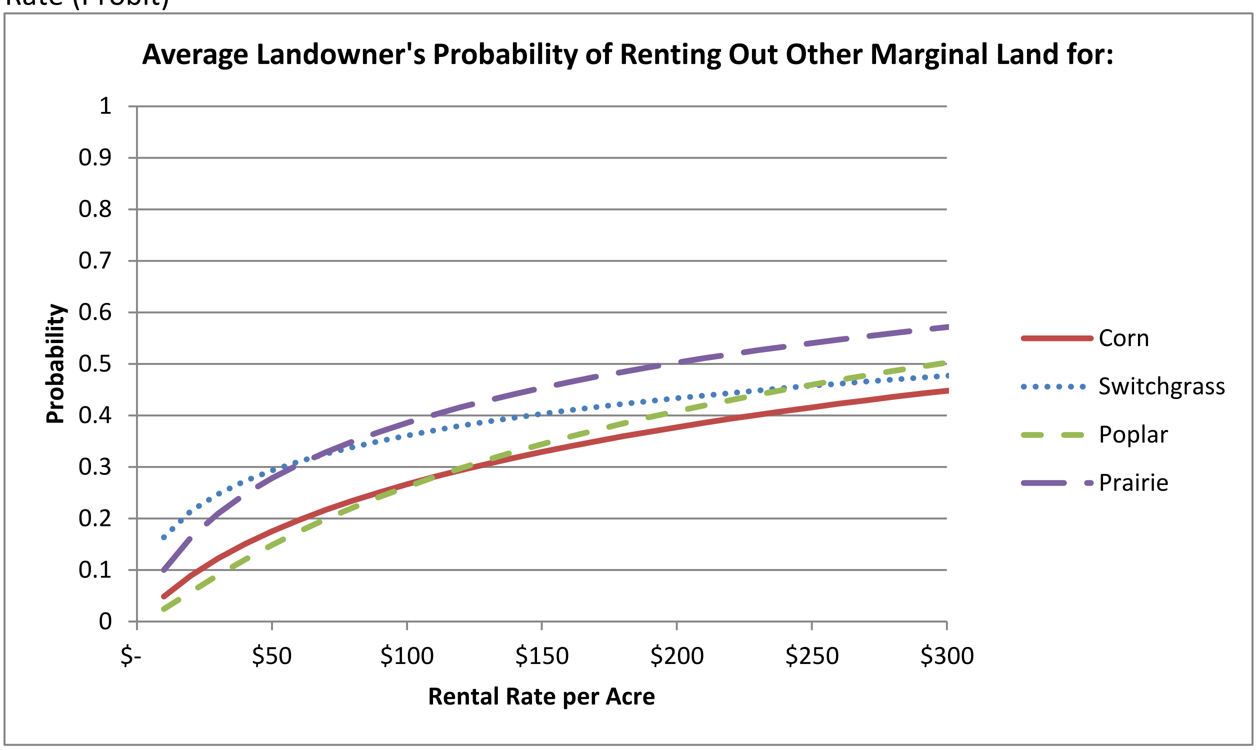


Figure 7. Probability of Renting Other Marginal Land for Bioenergy Crops in Response to Rental Rate (Probit)



9.2 The Acreage Commitment Model Results

The acreage commitment model captures how many acres an individual landowner is willing to rent, given that they have already decided to rent out some land. The results of the truncated models for the four different bioenergy crops on the three different land types can be seen in Tables 14-16. These results include parameter estimates and standard errors for each model. These parameter estimates can be thought of as the change in the number of acres a landowner is willing to rent for a unit change in the explanatory variable.

The most consistently significant influence on the acreage commitment decision was how much land the respondent owned. This result is quite logical as the amount of land a landowner owns directly limits how much is available to rent. However, what is interesting is the variation in these coefficients from one land type to the next. Each additional acre of cropland a landowner owns almost directly correlates with an additional acre of cropland that they are willing to rent, as seen by the coefficients 0.85, .99, 1.02, and .94 prairie, poplar, switchgrass, and corn in Tables 14a and 14b. On pasture and hay land the coefficients for this same land type are similar at 1.05, 1.11, 0.96, and 0.61 across the same four bioenergy crops (Tables 15a and 15b). However, on other marginal lands these coefficients fall sharply to 0.47, 0.32, 0.27, and 1.11 (Tables 16a and 16b). These results suggest that landowners in general are willing to rent out for bioenergy crops a much higher proportion of their crop and pasture land than their marginal land.

Table 17. Truncated Acreage Model for Cropland Committed to Prairie and Poplar

	Prairie Coef.	**(n=70)** Z-score	**Poplar** Coef.	**(n=52)** Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.98	0.21	-4.13	-0.79
Contract length (yrs)	1.28	0.78	1.93	1.12
Current Land Management:				
Currently Rents Land (0/1)	9.56	1.24	0.28	0.04
Current Land Owned:				
Total Cropland (acres)	0.85	8.68***	0.99	242.99***
Total Pasture (acres)	-0.016	-0.15	-0.11	-1.12
Total Other Land (acres)	-0.11	-1.28	0.13	2.21**
Total CRP Land (acres)	0.15	1.26	0.17	2.44**
Current Land Uses:				
Group of Non-Land Based Uses	8.00	1.44	-10.57	-3.86***
Group of Hunting Related Uses	-6.18	-0.80	-2.99	-0.86
Grazing Livestock (0/1)	-8.92	-0.70	2.05	0.25
Commercial Income (0/1)	-18.05	-1.82*	8.54	0.75
Conservation Income (0/1)	9.92	0.96	-12.96	-1.30
Environmental Factors:				
Renewable Energy	10.85	2.23**	3.20	0.73
General Environmentalism	3.50	0.87	8.76	2.5**
Concerns Factors:				
Agricultural Based	-1.22	-0.27	-0.93	-0.44
Renting Land Based	-6.68	-1.57	6.77	1.52
Demographic Information:				
Age (yrs)	1.03	2.35**	0.42	1.58
Male (0/1)	2.30	0.24	-21.65	-1.71*
Farmer (0/1)	4.51	0.53	-7.55	-0.90
Income (scale 1-6)	-2.66E-05	-0.57	9.87E-05	3.03***
Constant	-103.83	-1.85*	4.74	0.10
Log Likelihood Values	-4817.92		-3224.46	
Wald Chi-Squared	920.59		1.20	
Probability Chi-Squared	0.00		0.00	

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

Table 18. Truncated Acreage Model for Cropland Committed to Switchgrass and Corn

	Switch grass Coef.	**(n=77)** Z-score	**Corn** Coef.	**(n=77)** Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.00	0.00	50.75	1.50
Contract length (yrs)	-2.51	-1.47	8.19	1.02
Current Land Management:				
Currently Rents Land (0/1)	31.35	2.28**	-46.26	-0.91
Current Land Owned:				
Total Cropland (acres)	1.02	124.15***	0.94	23.79***
Total Pasture (acres)	0.38	3.27***	-1.48	-13.39***
Total Other Land (acres)	-0.31	-3.21***	0.56	1.7*
Total CRP Land (acres)	0.15	1.36	0.19	0.76
Current Land Uses:				
Group of Non-Land Based Uses	-4.54	-1.7*	-4.50	-0.36
Group of Hunting Related Uses	11.79	2.52**	10.69	0.44
Grazing Livestock (0/1)	12.23	1.31	125.96	2.57**
Commercial Income (0/1)	-14.49	-1.81*	36.23	0.78
Conservation Income (0/1)	-4.59	-0.47	84.67	1.9*
Environmental Factors:				
Renewable Energy	3.03	0.64	-9.73	-0.47
General Environmentalism	-2.93	-0.77	17.03	0.91
Concerns Factors:				
Agricultural Based	-2.38	-0.64	-16.92	-1.17
Renting Land Based	-2.77	-0.61	16.97	0.84
Demographic Information:				
Age (yrs)	0.99	2.04**	1.86	1.16
Male (0/1)	-0.38	-0.03	5.38	0.09
Farmer (0/1)	-5.92	-0.68	-10.93	-0.37
Income (scale 1-6)	7.65E-05	0.73	2.94E-04	1.41
Constant	-88.32	-1.77*	-586.45	-2.16**
Log Likelihood Values	-4956.01		-6494.08	
Wald Chi-Squared	1.90		29746.79	
Probability Chi-Squared	0.00		0.00	
Pseudo R-Squared				

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

Table 19. Truncated Acreage Model for Pasture and Hay Land Committed to Prairie and Poplar

	Prairie	**(n=102)**	**Poplar**	**(n=58)**
	Coef.	Z-score	Coef.	Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.27	0.09	-8.02	-1.42
Contract length (yrs)	0.73	0.91	-1.18	-1.20
Current Land Management:				
Currently Rents Land (0/1)	-4.64	-0.98	-4.42	-0.52
Current Land Owned:				
Total Cropland (acres)	0.034	1.35	0.0036	0.60
Total Pasture (acres)	1.05	54.45***	1.11	30.52***
Total Other Land (acres)	-0.13	-3.34***	-0.024	-0.24
Total CRP Land (acres)	-0.022	-1.12	-0.22	-1.55
Current Land Uses:				
Group of Non-Land Based Uses	-3.75	-2.7***	-7.94	-2.61***
Group of Hunting Related Uses	3.37	1.00	5.38	1.00
Grazing Livestock (0/1)	-7.65	-1.32	-17.61	-1.68*
Commercial Income (0/1)	-1.97	-0.37	14.98	1.73*
Conservation Income (0/1)	4.02	0.87	-1.69	-0.21
Environmental Factors:				
Renewable Energy	-3.38	-1.45	-0.85	-0.24
General Environmentalism	-0.55	-0.31	2.38	0.83
Concerns Factors:				
Agricultural Based	-1.62	-0.73	5.27	1.68*
Renting Land Based	-4.58	-1.98**	-1.98	-0.56
Demographic Information:				
Age (yrs)	0.28	1.46	0.33	1.06
Male (0/1)	-8.79	-1.83*	-12.94	-1.77*
Farmer (0/1)	2.39	0.66	1.59	0.20
Income (scale 1-6)	-9.81E-06	-0.26	2.26E-05	0.49
Constant	-21.78	-0.85	32.31	0.86
Log Likelihood Values	-6206.49		-3525.63	
Wald Chi-Squared	41739.70		4861.62	
Probability Chi-Squared	0.00		0.00	

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

Table 20. Truncated Acreage Model for Pasture and Hay Land Committed to Switchgrass and Corn

	Switch grass Coef.	**(n=88)** Z-score	**Corn** Coef.	**(n=79)** Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	0.96	0.22	-16.38	-1.00
Contract length (yrs)	-0.05	-0.07	1.69	0.64
Current Land Management:				
Currently Rents Land (0/1)	-7.75	-1.48	-15.86	-1.18
Current Land Owned:				
Total Cropland (acres)	0.010	2.21**	-0.029	-1.05
Total Pasture (acres)	0.96	18.33***	0.61	6***
Total Other Land (acres)	-0.21	-3.28***	0.25	1.35
Total CRP Land (acres)	-0.27	-4.49***	0.41	4.03***
Current Land Uses:				
Group of Non-Land Based Uses	-0.63	-0.41	3.04	0.33
Group of Hunting Related Uses	10.10	2.14**	-6.78	-0.46
Grazing Livestock (0/1)	4.73	0.55	4.14	0.26
Commercial Income (0/1)	-6.87	-1.08	-0.43	-0.02
Conservation Income (0/1)	9.95	1.7*	29.83	1.06
Environmental Factors:				
Renewable Energy	-2.86	-1.15	-0.36	-0.05
General Environmentalism	0.82	0.50	-5.72	-0.90
Concerns Factors:				
Agricultural Based	-0.38	-0.21	-0.70	-0.10
Renting Land Based	-7.35	-2.61***	-18.24	-1.39
Demographic Information:				
Age (yrs)	0.45	2.19**	0.78	1.36
Male (0/1)	-5.88	-1.15	-21.66	-1.05
Farmer (0/1)	6.31	1.96*	-8.60	-0.70
Income (scale 1-6)	6.39E-05	1.89*	-6.28E-05	-0.57
Constant	-49.19	-1.98**	19.07	0.25
Log Likelihood Values	-5548.03		-6288.57	
Wald Chi-Squared	5172.99		2109.32	
Probability Chi-Squared	0.00		0.00	
Pseudo R-Squared				

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

Table 21. Truncated Acreage Model for Other Marginal Lands Committed to Prairie and Poplar

	Prairie	**(n=137)**	**Poplar**	**(n=112)**
	Coef.	Z-score	Coef.	Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	18.16	1.27	272.14	1.33
Contract length (yrs)	4.43	1.22	25.23	1.06
Current Land Management:				
Currently Rents Land (0/1)	32.81	1.77*	-94.24	-0.96
Current Land Owned:				
Total Cropland (acres)	-0.10	-0.99	-0.019	-0.29
Total Pasture (acres)	0.50	2.01**	1.98	1.31
Total Other Land (acres)	0.47	2.11**	0.32	1.07
Total CRP Land (acres)	-0.31	-1.30	-2.84	-1.20
Current Land Uses:				
Group of Non-Land Based Uses	-11.08	-1.9*	-75.21	-1.24
Group of Hunting Related Uses	9.31	0.79	-14.11	-0.36
Grazing Livestock (0/1)	19.34	0.99	-94.60	-0.79
Commercial Income (0/1)	-16.66	-0.99	102.49	0.98
Conservation Income (0/1)	49.77	2.24**	104.02	0.94
Environmental Factors:				
Renewable Energy	11.02	1.88*	-48.17	-1.08
General Environmentalism	-0.26	-0.04	59.22	1.05
Concerns Factors:				
Agricultural Based	-12.05	-1.67*	-134.50	-1.36
Renting Land Based	-29.23	-2.8***	-65.85	-1.55
Demographic Information:				
Age (yrs)	-0.36	-0.57	6.23	1.34
Male (0/1)	1.01	0.04	-28.22	-0.28
Farmer (0/1)	0.94	0.06	77.26	0.69
Income (scale 1-6)	-1.44E-04	-1.32	-4.09E-04	-1.24
Constant	-166.65	-1.56	-2189.05	-1.37
Log Likelihood Values	-9476.71		-8156.93	
Wald Chi-Squared	61.72		48.96	
Probability Chi-Squared	0.00		0.00	

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

Table 22. Truncated Acreage Model for Other Marginal Lands Committed to Switchgrass and Corn

	Switch grass Coef.	**(n=121)** Z-score	**Corn** Coef.	**(n=102)** Z-score
Experimental Variables:				
Ln Rental Rate ($/acre)	-17.29	-0.66	-81.13	-0.72
Contract length (yrs)	6.75	0.83	37.61	1.12
Current Land Management:				
Currently Rents Land (0/1)	29.85	0.71	-2.74	-0.02
Current Land Owned:				
Total Cropland (acres)	0.034	1.32	-0.029	-0.31
Total Pasture (acres)	0.73	1.46	0.37	0.99
Total Other Land (acres)	0.27	1.86*	1.11	1.98**
Total CRP Land (acres)	0.99	1.21	2.83	0.84
Current Land Uses:				
Group of Non-Land Based Uses	-26.12	-1.40	112.75	1.39
Group of Hunting Related Uses	25.55	0.81	-254.20	-1.42
Grazing Livestock (0/1)	44.85	0.96	374.13	1.66*
Commercial Income (0/1)	15.99	0.40	-498.85	-1.69*
Conservation Income (0/1)	-11.50	-0.28	482.98	1.76*
Environmental Factors:				
Renewable Energy	-22.18	-1.23	20.53	0.32
General Environmentalism	32.95	1.47	70.99	1.12
Concerns Factors:				
Agricultural Based	-12.35	-0.77	-147.50	-1.55
Renting Land Based	-41.54	-1.45	-175.72	-1.60
Demographic Information:				
Age (yrs)	0.96	0.60	6.83	1.22
Male (0/1)	-28.21	-0.47	271.99	1.04
Farmer (0/1)	49.09	1.19	44.13	0.28
Income (scale 1-6)	-1.50E-07	0.00	-2.32E-05	-0.03
Constant	-218.66	-1.03	-1461.35	-1.36
Log Likelihood Values	-8677.74		-7757.02	
Wald Chi-Squared	99.83		12.45	
Probability Chi-Squared	0.00		0.90	
Pseudo R-Squared				

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

Unlike the participation model, in the acreage commitment model the variables related to how the current landowner uses the land were significant; however, these variables mostly had negative coefficient estimates. This pattern suggests that the more uses an owner has for the land, the fewer acres they are willing to enroll. This is consistent with the conceptual model, which found that some amenities to the landowner may disappear or diminish as the land changes use into bioenergy crops, thus causing the landowner to rent less land.

As in the participation models, so too in the acreage commitment models, landowner concerns with renting their land for bioenergy crops were significant and reduced the number of acres they were willing to enroll. This again supports the common idea that the more concerned an individual is about growing bioenergy crops on their land or getting involved in a rental contract, the less likely they are to rent out their land and the fewer acres they may be willing to provide.

One explanatory variable that was notably insignificant in all of the 12 truncated regressions was the rental rate offered. It appears from the results and from survey pretest interviews with landowners that while the rental rate offered does affect their decision to rent, it does not affect the amount they will rent once they have agreed to rent. From our discussions with landowners, this is most likely because they perceive their land in discrete parcels, and if they like a rental rate then they are likely to rent out the whole parcel for the new use and not just a portion of it. This leads us to reject Hypothesis 1b that rental rate has an effect on the area of land that landowners are willing to commit.

How much land is the average landowner willing to rent for cropland compared to pasture and other marginal lands? The amount of cropland that the average landowner who owns cropland said they would rent at a typical $100 per acre rental rate was generally over 120 acres, while the average landowner who owns pasture and other marginal lands was willing to rent a combined total of 90 acres. This result is based upon the fact that the average land holding of cropland was larger than that of pasture and or of marginal lands. These values and further individual crop-based results can be seen in Figure 8.

The distribution of land holdings by area owned was highly skewed among survey respondents. Figure 9 shows a Lorenz style curve displaying the amount of different land types owned at each percentile. The graph shows that even though survey respondents were targeted according to the amount of pasture land and other marginal lands they owned, the entire group of respondents owns in total about an equal area of cropland. This finding confirms Hypothesis 6 which states that, “Most landowners who own marginal land will own cropland as well.” The Lorenz style curve also shows that the larger landowners own a high proportion of the land. In fact the top 10% of cropland landowners own 80% of the potential cropland, the top 10% of pasture and hay landowners own 70% of the potential pasture and hay lands, and the top 10% of other marginal land landowners own 50% of the potential other marginal land.

Figure 8. Average Acreage Offered Conditional on Renting Land for Bioenergy Crops at $100 per Acre (Truncated Model)

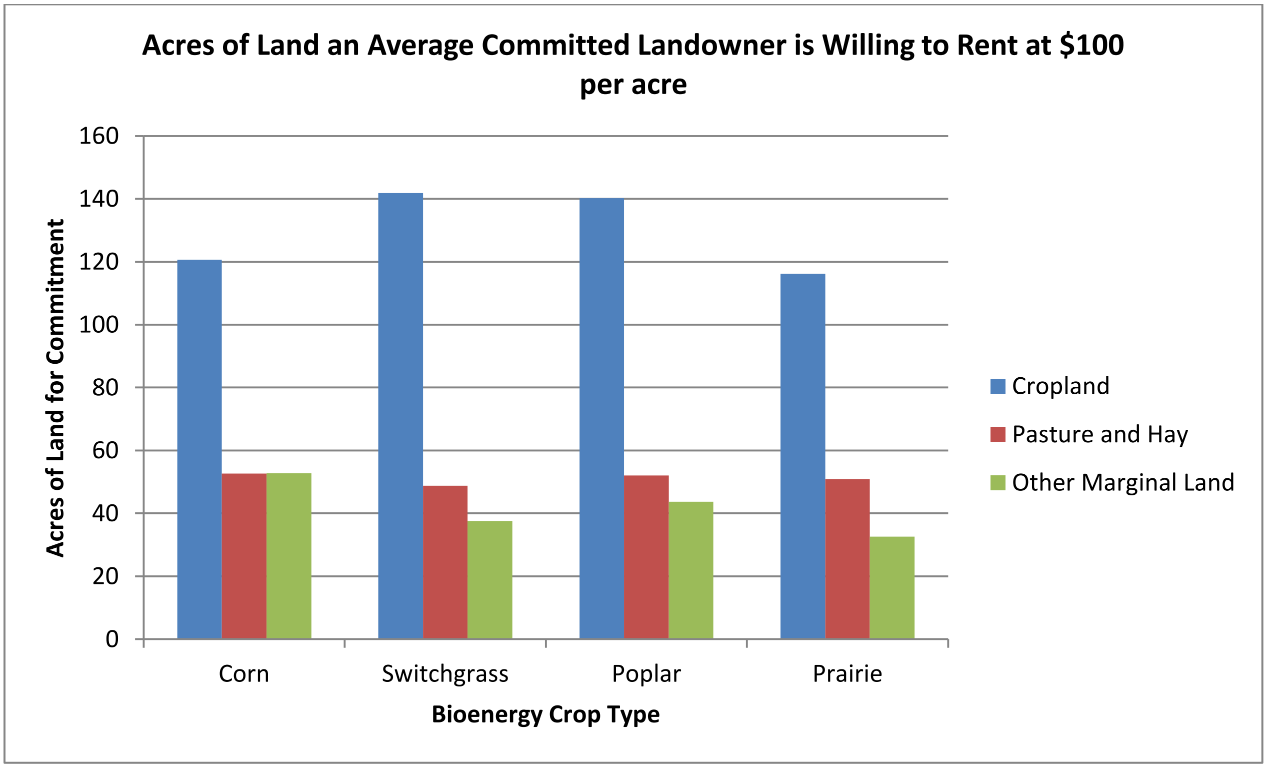
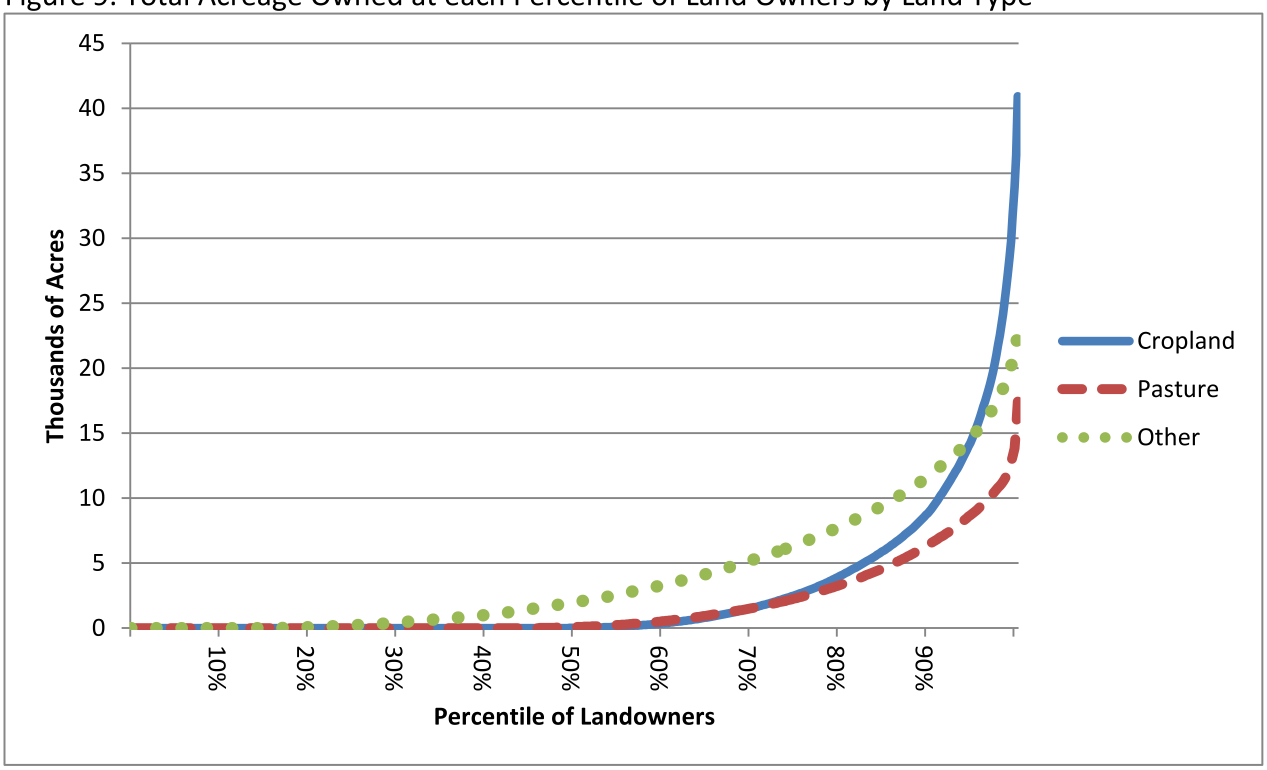


Figure 9. Total Acreage Owned at each Percentile of Land Owners by Land Type



9.3 Scaling up Results to Southern Lower Michigan

The results from the participation model and the acreage commitment model were first combined to create a description of the average southern Lower Michigan landowner (Figures 10-12). These results show is that the average owner of marginal land, at a typical rental rate of $100 per acre, is willing to rent out about 20 to 30 acres of cropland and about 30 acres of marginal land (defined as the combination of pasture and other marginal land from the survey which includes hay, pasture, scrubland, grassland, idle land, and other farmable non-crop lands). From the truncated regression results and the Lorenz land curve (Figure 9) it is apparent that owners of marginal land often own more cropland than marginal land. But on average they are willing to rent similar amounts of it at the same price. However, the price elasticity of land supply is much greater for cropland than pasture and other marginal land, meaning that a change in price affected the supply of cropland much more than the supply of pasture or other marginal land.

Figure 10. Average Landowner Supply of Cropland for Bioenergy Crops (Combined Participation and Acreage Commitment Models)

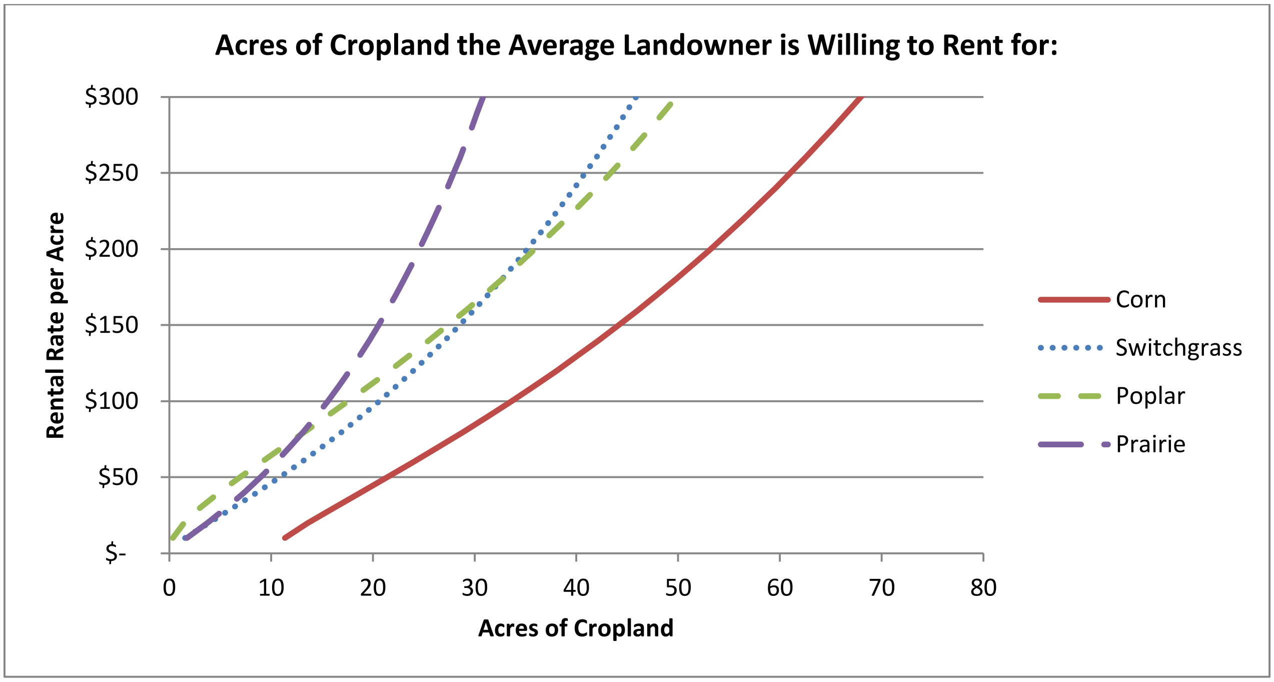


Figure 11. Average Landowner Supply of Pasture Land for Bioenergy Crops (Combined Participation and Acreage Commitment Models)

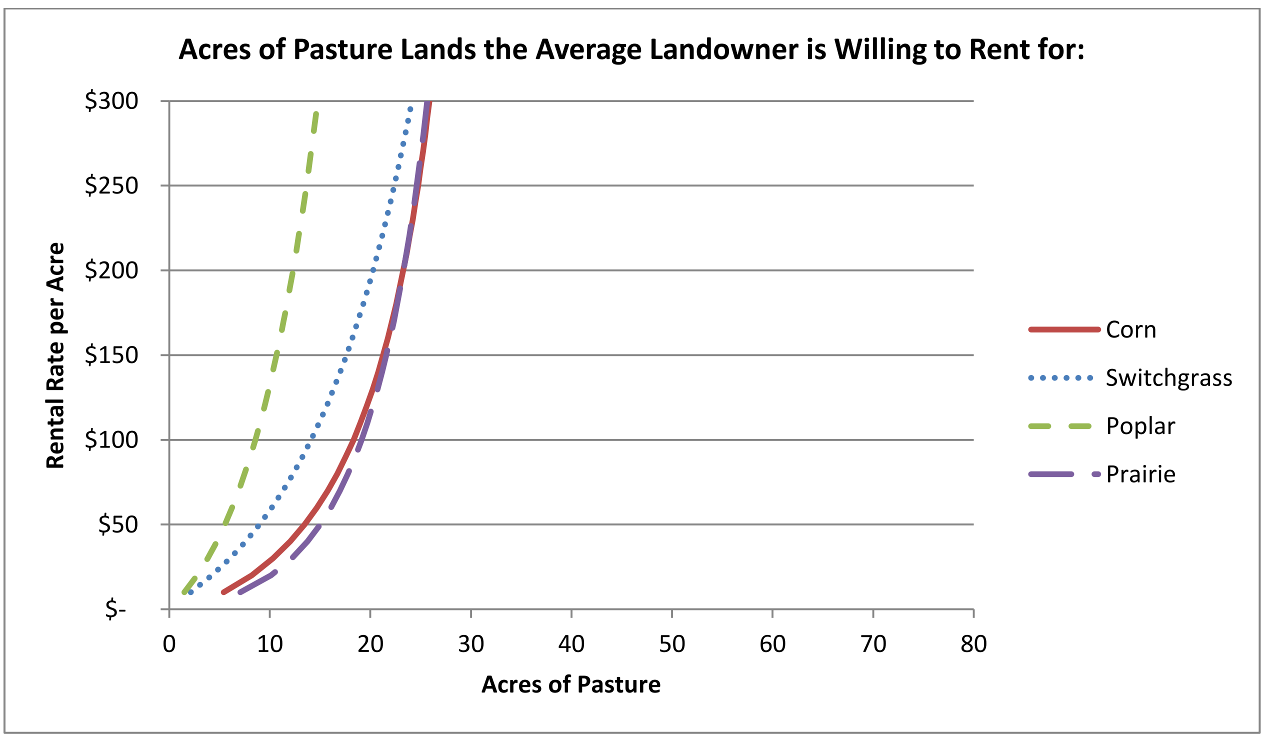
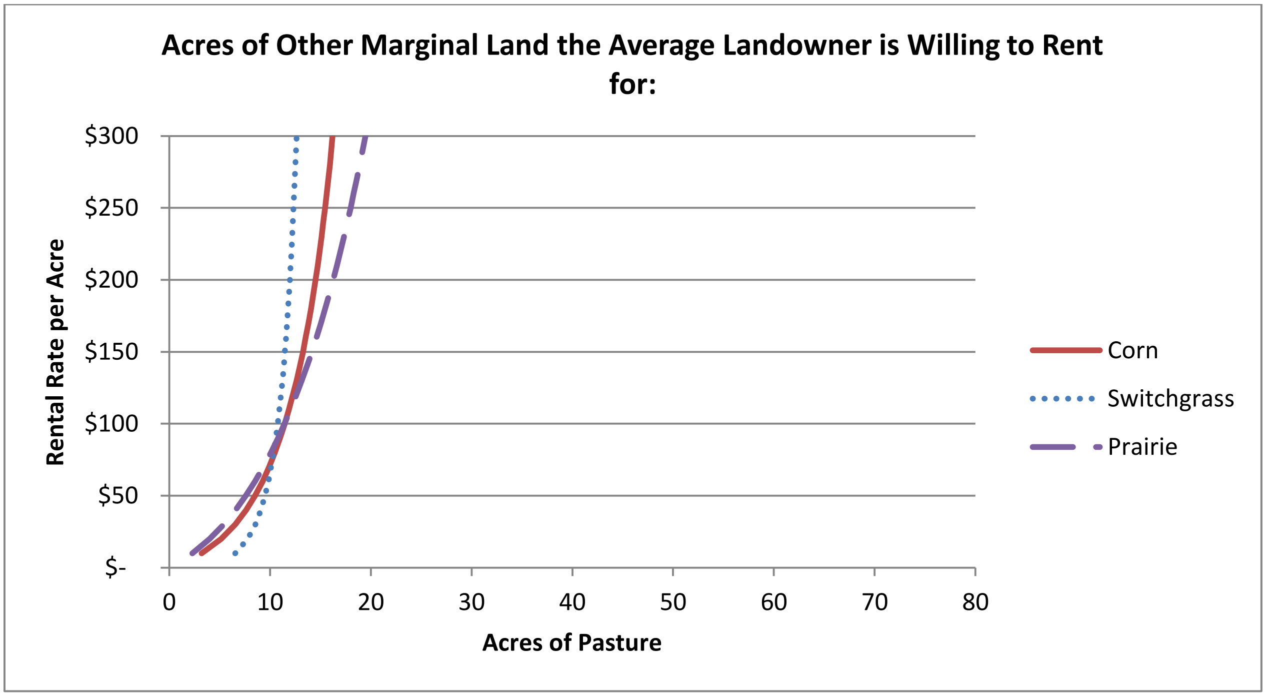


Figure 12. Average Landowner Supply of Other Marginal Land for Bioenergy Crops (Combined Participation and Acreage Commitment Models)

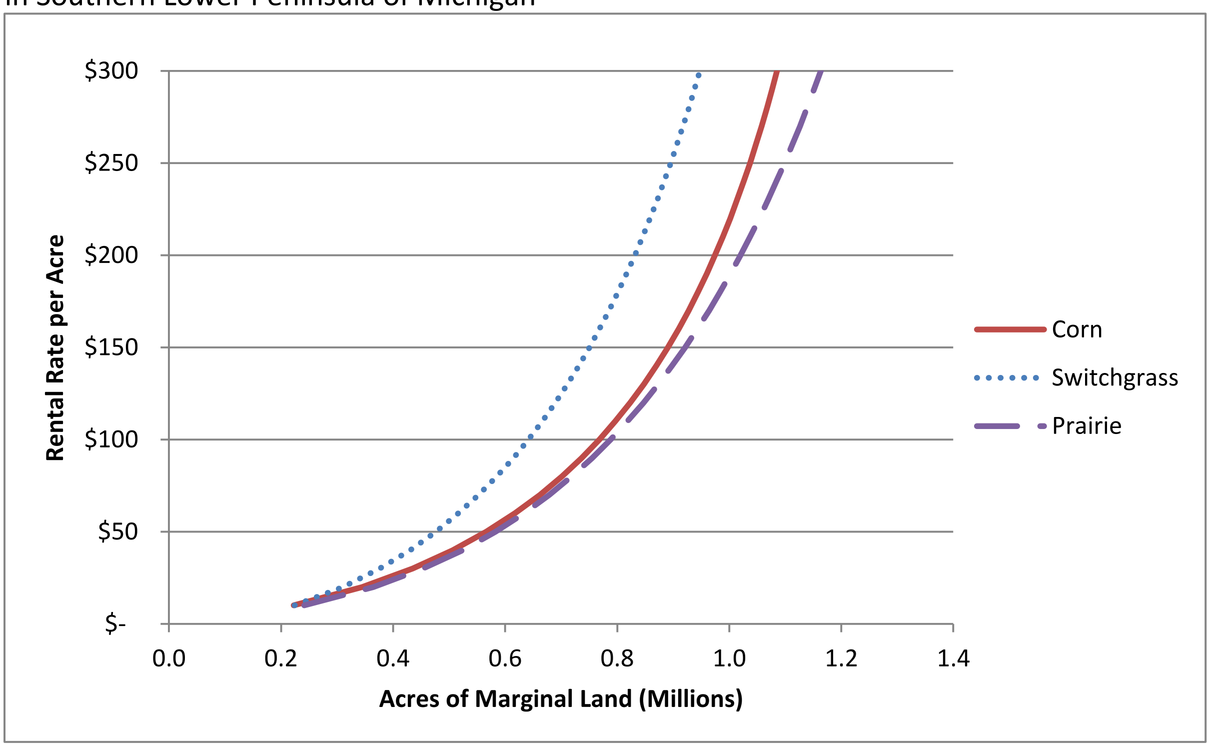


*Poplar omitted due to insignificance of price response to rental rate.

The supply of land for hybrid poplar other marginal lands is omitted from the graph for the average landowner (Figure 12). As mentioned above, the rental rate coefficient estimate was statistically insignificant in both the poplar participation model and the poplar acreage commitment model. However, the coefficient for rental rate was quite high, over 272 for hybrid poplar on other marginal lands (Table 16a). The large but insignificant coefficient gave the misleading impression that renting land for poplar was very desirable at high rental rates.

The results from scaling the average individual landowner up to create a supply function of land for bioenergy crops in Southern Lower Michigan can be seen in Figure 13 (where Southern Lower Michigan is the southern half of the lower peninsula of Michigan). This figure was created, as described in Chapter 7, by estimating the total number of landowners who own over ten acres of marginal land and multiplying that by the average acres committed from the combined model for pasture and other marginal lands. Figure 13 shows a maximum of around 1.2 million acres being available at very high rental rates of $300 per acre and around 0.8 million acres being available at a typical rental rate of $100 per acre. Given that the estimated amount of marginal land in Southern Lower Michigan is around three million acres, as shown in Chapter 5, we can see that at $100 per acre, only about 26% of existing marginal land would actually be supplied for bioenergy crops. This result is consistent with Hypothesis 3 stating that many landowners will be unwilling to rent out their land for bioenergy crops. Note that the scaled up results in Figure 13 omit the land supply for hybrid poplar for the same reason that it was omitted from the average landowner results on other marginal lands, because poplar does not show statistically clear price response.

Figure 13. Supply of Marginal Land (Pasture + Other Marginal Lands) for Three Bioenergy Crops in Southern Lower Peninsula of Michigan



*Poplar omitted due to insignificance of price response to rental rate.

Chapter 10: Conclusion

This thesis contributes to the literature on the potential of growing bioenergy crops on marginal land by exploring the difference between the amount of marginal land that exists and the amount that owners would be willing to make available for bioenergy crop production. Marginal land is defined as rural land not currently in crops that has the potential to produce bioenergy crops, including grassland, hay, pasture, scrubland, fallow land, and idle land. Previous studies have shown that using marginal land to grow bioenergy crops instead of cropland would result in reduced effects on food prices (Searchinger et al. 2008; Rajagopal et al. 2007; Fritsche 2008). Some studies have tried to measure the amount of marginal land that would potentially be available for energy biomass production (e.g., Gelfand et al. in 2013 for the Midwestern U.S.A.). However, no studies have yet looked into the willingness of owners of marginal land to grow bioenergy crops. In this study we identified owners of marginal land in southern Lower Michigan and through a survey we elicited their willingness to rent their marginal land for bioenergy production at various rental rates.

We found that owners of marginal land in Michigan were not willing to rent all of their marginal land, even at very high rental rates. In fact when the responses of individual landowners were scaled up to cover Southern Lower Michigan we found we could only expect about 26% of all marginal land to become available at a typical crop rental rate of $100 per acre. Along with this, we discovered that owners of marginal land often own cropland as well.

When asked what land they would be willing to rent for bioenergy crops at specified rental rates, they were willing to provide cropland and marginal land in similar amounts. These findings are consistent with the conceptual framework that stated landowners maximize utility, and the utility they receive in amenities from keeping their land use unchanged can outweigh the gain in utility they might receive from rental income and the additional consumption that it makes possible.

These findings point towards a number of difficulties on the road ahead for bioenergy from marginal land. First, they show that owners of marginal land are willing to make less land available to grow bioenergy crops than had previously been estimated by studies such as the Billion Ton Report (U. S. Department of Energy). Second, they show that if a market to grow bioenergy crops did exist, then landowners would choose on cropland rather than marginal non-crop land to grow a significant portion of these bioenergy crops. In turn, this would lead to bioenergy production having an impact on food prices. While this study of landowner willingness to supply marginal land is limited to southern Lower Michigan, these two general findings indicate that landowner preferences must be considered in any future estimate of large scale bioenergy production potential. Failure to do so would result in overestimating the amount of land available for bioenergy crops and possibly lead to exaggerated expectations for bioenergy crop production on marginal lands. In fact, landowners will dictate where and how much energy crops will be grown.

APPENDIX

Figure 14 Pre-survey Postcard

MICHIGAN STATE
UNIVERSITY

Bioenergy and Land Use Survey
Dept. of Agricultural, Food, and Resource Economics
202 Agriculture Hall
East Lansing, MI 48824-1039

«Owner_Name»
«Address»
«City», «State» «Zipcode»

MICHIGAN STATE
UNIVERSITY

Dear «Owner_Name»,

In a few days, you will receive a questionnaire about bioenergy and your land. I hope that you will take 20 minutes to fill it out and mail it back. I am letting you know this now since many people like to receive notice in advance.

You are one of a small number of land owners who are being asked to express their opinions about bioenergy. It is very important that you reply so that the results give the clearest possible picture of how future policies can help Michigan landowners.

Thank you in advance for your help.

Sincerely,

Scott M. Swinton
Professor

Figure 15 Cover Letter

MICHIGAN STATE
UNIVERSITY

April 6, 2012

«Owner_Name»
«Address»
«City», «State» «Zipcode»

Dear «Owner_Name»,

I would like to ask you about your views on your land, bioenergy, and the environment. You are one of a small number of people whose opinions we are consulting as part of a research project. You received this survey because we believe that you own some land that is not used for growing crops but could be used to grow plants for bioenergy. I would like your help in understanding how landowners make decisions about their land in connection with the possibility of making it available for bioenergy crops.

By completing this questionnaire you are providing vital information about the potential of U.S. land to grow bioenergy crops. I realize that your time is valuable and hope you will consider taking 20 minutes to fill out the attached questionnaire and return it to me in the prepaid envelope. To participate in this survey you do not need any special knowledge about energy or farming.

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 refuse to answer certain questions or withdraw from the study by replying that you prefer not to participate (or by not replying at all).

I would be most happy to answer any questions you might have. You can contact me by phone at (517) 353-7218, by email at swintons@msu.edu, or by postal mail at Dept. of Agricultural, Food and Resource Economics, 202 Agriculture Hall, Michigan State University, East Lansing, MI 48824-1039.

Thank you for your time and help. As a gesture of appreciation, I enclosed a one dollar bill.

Sincerely,

Scott M. Swinton, Professor

P.S. – If by chance you are not a rural landowner, please answer just the first question and return the questionnaire in its prepaid envelope.

COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

Department of Agricultural, Food, and Resource Economics

Michigan State University
Agriculture Hall
East Lansing, MI
48824-1039

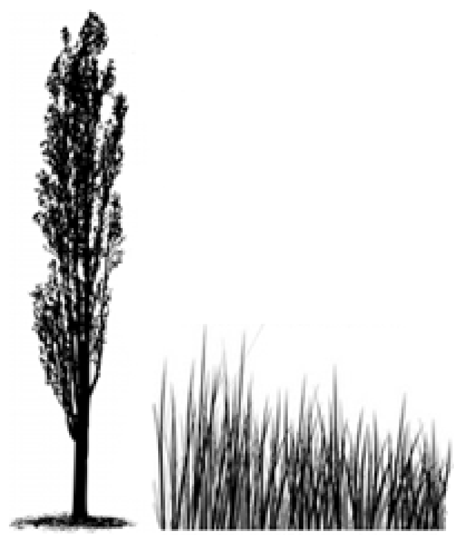
Fax: 517/432-1800
Web: www.aec.msu.edu

Figure 16 Example Survey

MICHIGAN STATE
UNIVERSITY

BIOENERGY AND LAND USE

WE NEED YOUR HELP!



The purpose of this survey is to understand your views about bioenergy. There are no right or wrong answers because people have different attitudes and uses for their land.

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 landowners.

Figure 16 (cont'd)

WHO SHOULD FILL OUT THIS SURVEY

1. Do you own over 10 acres of rural land, land that is grassland, forest, or farmland?
   - ☐ No ⇨ If you answered NO, please stop filling out the survey now and mail it in the provided prepaid envelope. Thank you for your response!
   - ☐ Yes

2. Are you the main decision maker for land management for your rural land?
   - ☐ No ⇨ If you answered NO, please give this questionnaire directly to the person who makes the land management decisions for your rural land.
   - ☐ Yes

SECTION A: YOUR CURRENT LAND MANAGEMENT PRACTICES

A1. Do you own rural land in more than one location?

☐ No

☐ Yes

A2. What is the county where most of your rural land is located? ________________

A3. Do you currently rent out any of your rural land to others?

☐No *(please go to A7)*

☐ Yes

IF YOU ANSWERED YES:

A4. How many acres of your rural land did you rent out in 2011? ______ACRES

A5. What was the most common rental rate for your land? $______PER ACRE

A6. <u>Not</u> including land that you may have rented out to others, did you grow any commercial crops on the rural land you own in 2011?

☐Yes

☐ No

A7. How much longer do you plan to own the majority of your rural land?

☐Less than 1 year

☐1 to 5 years

☐5 to 10 years

☐More than 10 years

☐For the rest of my life

A8. How would you describe what is on the rural land you own?

Figure 16 (cont'd)

Description	Acres of Rural Land
CROPLAND	
Corn	______ ACRES
Soybeans	______ ACRES
Wheat	______ ACRES
Other row crops	______ ACRES
Fruit trees or plants	______ ACRES
Vegetables	______ ACRES
HAY AND PASTURE LAND	
Grassland or Pasture	______ ACRES
Hay or Alfalfa	______ ACRES
FARMABLE NON-CROP LAND (Could be farmed if cleared)	
Forest	______ ACRES
Shrub or Scrub (low growth with bushes or few trees)	______ ACRES
Other potentially farmable land	______ ACRES
OTHER	
Any other rural land (Wetlands, lawn and garden, not farmable land.)	______ ACRES
Other (please specify):________________________________	______ ACRES
Other (please specify):________________________________	______ ACRES

A9. Total number of acres of rural land that you own: ______ **ACRES**

Figure 16 (cont'd)

A10. How do you or other family members use the different types of rural land that you own?

	I use my rural land for this purpose: (Check all that apply)
As scenery or for a desired view	☐
Physical activities (walking, *running, or sports)*	☐
Recreational vehicle use (4x4, quads, or dirt bikes)	☐
Hunting and Fishing	☐
For grazing livestock (Cattle, sheep, horses, pigs, etc.)	☐
Commercial crops or garden income	☐
For conservation program income	☐
For a home or second home	☐
For firewood	☐
Food plots for deer or other game	☐
Other use (please specify): ______________________	☐
Other use (please specify): ______________________	☐
Other use (please specify): ______________________	☐

Figure 16 (cont'd)

A11. Please check the box that best represents your agreement with the following statements related to your land and land use.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I would never sell the rural land that I own.	☐	☐	☐	☐	☐
I would be willing to sell my land if I knew it was going to be used for agriculture.	☐	☐	☐	☐	☐
I would consider renting the rural land that I own.	☐	☐	☐	☐	☐
I would allow someone renting my rural land to store bales of hay or straw on it for a few months each year.	☐	☐	☐	☐	☐
My family or friends would prefer that I <u>not</u> rent my rural land to grow crops.	☐	☐	☐	☐	☐
Sometime in the next 10 years I plan to change the way I use my rural land.	☐	☐	☐	☐	☐

Figure 16 (cont'd)

PART B: BIOENERGY AND BIOENERGY CROPS

BIOENERGY is energy that comes from a biological source, such as crops, grasses, or trees. These sources are often called bioenergy crops. These crops can be burned to generate heat or electricity. They can also be refined to make a liquid fuel, such as ethanol. Today, the most common form of ethanol in the United States comes from corn grain. It is possible, however, to make ethanol from other plants as well.

B1. Had you heard of bioenergy before?

☐ Yes

☐ No

B2. Did you know that ethanol can be produced from other sources besides corn grain?

☐ Yes

☐ No

B3. Did you know that many bioenergy crops can be grown on less fertile soil such as farmable non-crop land that may be currently in forest or shrubs?

☐ Yes

☐ No

CORN is the most common crop grown in the United States. Corn has a variety of uses from food and animal feed to corn syrup and ethanol. The non-grain parts of the corn plant (e.g., stalk, leaf, husk, and cob) are often left in the field following grain harvest. About half of these corn scraps need to be left on the field to provide nutrients and organic matter to the soil, while the other half can be used for bioenergy by either being burned or transformed into ethanol.

B4. Have you ever grown corn before?

☐ Yes

☐ No

B5. Were you aware that corn scraps could be used for bioenergy?

☐ Yes

☐ No

Figure 16 (cont'd)

SWITCHGRASS is a native, warm-season perennial grass. It is known for high yields that make it attractive for fuel production or heat and electricity generation. Because switchgrass is a perennial, there is no need to disturb the soil each year for planting and it requires less fertilizer than other bioenergy crops. Also, perennial switchgrass fields may provide habitat for birds, mammals and beneficial insects.

B6. Have you ever seen switchgrass before?

☐ Yes

☐ No

B7. Did you know that switchgrass is a perennial, so it only needs to be planted once every decade or so?

☐ Yes

☐ No

HYBRID POPLARS are fast-growing trees that are closely related to cottonwoods and aspens. They are grown in a way that makes them look more like row crops than a typical forest. Hybrid poplars need very little maintenance and fertilizer. As perennial trees they create relatively little greenhouse gas emissions. Also, hybrid poplars may offer a good habitat for birds, mammals and beneficial insects.

B8. Have you ever seen hybrid poplar trees planted in rows?

☐ Yes

☐ No

B9. Were you aware that perennials like poplar cause less greenhouse gases because the soil is not tilled every year?

☐ Yes

☐ No

MIXED PRAIRIE is a combination of different types of prairie grasses. Similar to switchgrass, it is a perennial so it does not need to be replanted. Because of this it requires less fertilizer than other bioenergy crops. Also, prairie grasses may offer a good habitat for birds, mammals and beneficial insects.

B10. Do you currently have any prairie grasses on your land?

☐ Yes

☐ No

B11. Did you know that mixed prairie offer what is called "functional diversity", which means that even though there are only a couple different species of grass they provide the benefits of a bio-diverse landscape?

☐ Yes

☐ No

Figure 16 (cont'd)

PART C: FOUR SPECIFIC BIOENERGY CROPPING SYSTEMS

The following four pages each show a specific bioenergy cropping system.

Please start by reading the description of the crop, considering what it might be like to rent out your rural land to grow the crop. Then mark the number of acres you would be willing to commit for the length of the contract at the given price. The different types of land you are asked about renting refers back to the land you described in Question A8 (Cropland, Hay and Pasture Land, and Farmable Non-Crop Land).

Think about the four different scenarios separately. In other words, when you are presented with a suggested offer to rent your land for a particular bioenergy crop, assume that that the other three offers do not exist as options.

We ask you to focus only on the scenarios we are proposing for each cropping system.

Figure 16 (cont'd)

CORN

Planted:	Every spring
Harvested:	Every fall
Fertilized:	Yearly
Average number of farmer visits:	7 per year
Maximum height:	7 to 10 feet
Production:	Grain and residues for Bioenergy
Soil erosion:	High compared to other bioenergy crops
Greenhouse gas emissions:	High compared to other bioenergy crops
Water contamination:	High compared to other bioenergy crops
Crop as a wildlife habitat:	Average compared to other bioenergy crops
Rental rate paid to you by farmer:	**$50 DOLLARS PER ACRE PER YEAR**
Length of contract:	**5 YEARS IN CORN**

C1. If somebody wanted to rent your existing cropland to grow corn for $50 an acre per year for 5 years, would you rent any of it out?

- ☐ Yes, I would be willing to rent out ⇨ _____ ACRES
- ☐ No (Choose one explanation)
  - ☐ I do not own any existing cropland.
  - ☐ I would not rent any of this type of land for this use no matter how high the rent was.
  - ☐ I would rent out this type of land for this use if the rent were higher.

C2. If somebody wanted to rent your existing hay and pasture land to grow corn for $50 an acre per year for 5 years, would you rent any of it out?

- ☐ Yes, I would be willing to rent out ⇨ _____ ACRES
- ☐ No (Choose one explanation)
  - ☐ I do not own any existing hay and pasture land.
  - ☐ I would not rent any of this type of land for this use no matter how high the rent was.
  - ☐ I would rent out this type of land for this use if the rent were higher.

C3. If somebody wanted to rent your existing farmable non-crop land to grow corn for $50 an acre per year for 5 years, would you rent any of it out? (The renter would be responsible for clearing costs. You would get any timber sales.)

- ☐ Yes, I would be willing to rent out ⇨ _____ ACRES
- ☐ No (Choose one explanation)
  - ☐ I do not own any existing farmable non-crop land.
  - ☐ I would not rent any of this type of land for this use no matter how high the rent was.
  - ☐ I would rent out this type of land for this use if the rent were higher.

Figure 16 (cont'd)

SWITCHGRASS

Planted:	Spring of the first year
Harvested:	Every fall after year 1 or 2
Fertilized:	Yearly
Average number of farmer visits:	3 per year
Maximum height:	4 to 6 feet
Production:	Bioenergy
Soil erosion:	Low compared to other bioenergy crops
Greenhouse gas emissions:	Average compared to other bioenergy crops
Water contamination:	Low compared to other bioenergy crops
Crop as a wildlife habitat:	Good compared to other bioenergy crops
Rental rate paid to you by farmer:	**$50 DOLLARS PER ACRE PER YEAR**
Length of contract:	**5 YEARS IN SWITCHGRASS**

C4. If somebody wanted to rent your existing cropland to grow switchgrass for $50 an acre per year for 5 years, would you rent any of it out?

- ☐ Yes, I would be willing to rent out ⇨ ______ ACRES
- ☐ No (Choose one explanation)
  - ☐ I do not own any existing cropland.
  - ☐ I would not rent any of this type of land for this use no matter how high the rent was.
  - ☐ I would rent out this type of land for this use if the rent were higher.

C5. If somebody wanted to rent your existing hay and pasture land to grow switchgrass for $50 an acre per year for 5 years, would you rent any of it out?

- ☐ Yes, I would be willing to rent out ⇨ ______ ACRES
- ☐ No (Choose one explanation)
  - ☐ I do not own any existing hay and pasture land.
  - ☐ I would not rent any of this type of land for this use no matter how high the rent was.
  - ☐ I would rent out this type of land for this use if the rent were higher.

C6. If somebody wanted to rent your existing farmable non-crop land to grow switchgrass for $50 an acre per year for 5 years, would you rent any of it out? (The renter would be responsible for clearing costs. You would get any timber sales.)

- ☐ Yes, I would be willing to rent out ⇨ ______ ACRES
- ☐ No (Choose one explanation)
  - ☐ I do not own any existing farmable non-crop land.
  - ☐ I would not rent any of this type of land for this use no matter how high the rent was.
  - ☐ I would rent out this type of land for this use if the rent were higher.

Figure 16 (cont'd)

HYBRID POPLAR TREES

Planted:	Spring of the first year
Harvested:	5-10 years after planting
Fertilized:	Every few years
Average number of farmer visits:	1 per year
Maximum height:	20 to 30 feet
Production:	Bioenergy
Soil erosion:	Average compared to other bioenergy crops
Greenhouse gas emissions:	Low compared to other bioenergy crops
Water contamination:	Average compared to other bioenergy crops
Crop as a wildlife habitat:	Average compared to other bioenergy crops
Rental rate paid to you by farmer:	**$300 DOLLARS PER ACRE PER YEAR**
Length of contract:	**10 YEARS IN POPLAR TREES**

C7. If somebody wanted to rent your existing cropland to grow hybrid poplar for $300 an acre per year for 10 years, would you rent any of it out?

☐ Yes, I would be willing to rent out ⇨ ______ ACRES

☐ No (Choose one explanation)

☐ I do not own any existing cropland.

☐ I would not rent any of this type of land for this use no matter how high the rent was.

☐ I would rent out this type of land for this use if the rent were higher.

C8. If somebody wanted to rent your existing hay and pasture land to grow hybrid poplar for $300 an acre per year for 10 years, would you rent any of it out?

☐ Yes, I would be willing to rent out ⇨ ______ ACRES

☐ No (Choose one explanation)

☐ I do not own any existing hay and pasture land.

☐ I would not rent any of this type of land for this use no matter how high the rent was.

☐ I would rent out this type of land for this use if the rent were higher.

C9. If somebody wanted to rent your existing farmable non-crop land to grow hybrid poplar for $300 an acre per year for 10 years, would you rent any of it out? (The renter would be responsible for clearing costs. You would get any timber sales.)

☐ Yes, I would be willing to rent out ⇨ ______ ACRES

☐ No (Choose one explanation)

☐ I do not own any existing farmable non-crop land.

☐ I would not rent any of this type of land for this use no matter how high the rent was.

☐ I would rent out this type of land for this use if the rent were higher.

Figure 16 (cont'd)

MIXED PRAIRIE

Planted:	Spring of the first year
Harvested:	Every Fall after year 1 or 2
Fertilized:	Yearly
Average number of farmer visits:	3 per year
Maximum height:	1 to 5 feet
Production:	Bioenergy
Soil erosion:	Low compared to other bioenergy crops
Greenhouse gas emissions:	Average compared to other bioenergy crops
Water contamination:	Low compared to other bioenergy crops
Crop as a wildlife habitat:	Excellent compared to other bioenergy crops
Rental rate paid to you by farmer:	**$300 DOLLARS PER ACRE PER YEAR**
Length of contract:	**5 YEARS IN MIXED PRAIRIE**

C10. If somebody wanted to rent your existing cropland to grow mixed prairie for $300 an acre per year for 5 years, would you rent any of it out?

- ☐ Yes, I would be willing to rent out ⇨ ______ACRES
- ☐ No (Choose one explanation)
  - ☐ I do not own any existing cropland.
  - ☐ I would not rent any of this type of land for this use no matter how high the rent was.
  - ☐ I would rent out this type of land for this use if the rent were higher.

C11. If somebody wanted to rent your existing hay and pasture land to grow mixed prairie for $300 an acre per year for 5 years, would you rent any of it out?

- ☐ Yes, I would be willing to rent out ⇨ ______ACRES
- ☐ No (Choose one explanation)
  - ☐ I do not own any existing hay and pasture land.
  - ☐ I would not rent any of this type of land for this use no matter how high the rent was.
  - ☐ I would rent out this type of land for this use if the rent were higher.

C12. If somebody wanted to rent your existing farmable non-crop land to grow mixed prairie for $300 an acre per year for 5 years, would you rent any of it out? (The renter would be responsible for clearing costs. You would get any timber sales.)

- ☐ Yes, I would be willing to rent out ⇨ ______ACRES
- ☐ No (Choose one explanation)
  - ☐ I do not own any existing farmable non-crop land.
  - ☐ I would not rent any of this type of land for this use no matter how high the rent was.
  - ☐ I would rent out this type of land for this use if the rent were higher.

Figure 16 (cont'd)

SECTION D: YOUR OPINIONS ON BIOENERGY, THE ENVIRONMENT, AND RENTING LAND.

D1. Please check the box that best represents your agreement with the following statements related to bioenergy and the environment.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Growing crops for renewable automotive fuel is necessary for our nation's future.	☐	☐	☐	☐	☐
Burning renewable plant-based resources for electricity instead of burning non-renewable resources such as coal is worth the extra cost.	☐	☐	☐	☐	☐
Humans have the right to modify the natural environment to suit their needs.	☐	☐	☐	☐	☐
Humankind is severely abusing the environment.	☐	☐	☐	☐	☐
The so-called "ecological crisis" facing humankind has been greatly exaggerated.	☐	☐	☐	☐	☐
The balance of nature is very delicate and easily upset.	☐	☐	☐	☐	☐
Renewable energy is <u>not</u> urgently needed right now.	☐	☐	☐	☐	☐

Figure 16 (cont'd)

D2. Please check the box that best represents your agreement with the following statements related to potential concerns with renting.

When I think about renting my land for bioenergy crops I am concerned with:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The potential smell	☐	☐	☐	☐	☐
Noise from harvesting, planting, or other activities	☐	☐	☐	☐	☐
Dust in the air	☐	☐	☐	☐	☐
Potential legal costs of contracting	☐	☐	☐	☐	☐
The length of the contract	☐	☐	☐	☐	☐
The possible need for insurance	☐	☐	☐	☐	☐
Having other people on my land	☐	☐	☐	☐	☐
The land changing so that I can no longer use it as I have	☐	☐	☐	☐	☐
The use of pesticide and fertilizer on my land	☐	☐	☐	☐	☐

Figure 16 (cont'd)

SECTION E: BACKGROUND INFORMATION

This last section asks for background information to help identify patterns among different kinds of landowners. Your answers here are very important and will be kept completely confidential.

E1. What is your age? ____________ (YEARS)

E2. What is your gender?

☐ Male ☐ Female

E3. Including yourself, how many members are in your household? ____________

E4. Are you a farmer or do you do farm work?

☐ Yes ☐ No

E5. How much is the annual pretax income of your household in 2010? Include net income from all sources (salary, wages, social security, rental properties, and investment income).

☐ Less than $25,000
☐ $25,000 to $49,999
☐ $50,000 to $99,999
☐ $100,000 to $149,999
☐ $150,000 to $199,999
☐ $200,000 and above

E6. What is the highest level of education you have completed?

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

E7. Is any part of your rural land restricted by zoning in any way? *(Check all that apply.)*

☐ Zoned for agricultural use
☐ Zoned for residential use
☐ Zoned for industrial use
☐ Not restricted by zoning
☐ I am uncertain

Figure 16 (cont'd)

(Optional) Do you have any comments?

____

____

____

____

THANK YOU

If you have questions about the research or any part of the questionnaire, contact Dr. Scott M. Swinton at 1-517-353-7218, by e-mail at swintons@msu.edu, or by postal mail at Department of Agricultural, Food, and Resource Economics, Michigan State University, East Lansing, MI 48824-1039.

Figure 17 Reminder Postcard

MICHIGAN STATE
UNIVERSITY

Bioenergy and Land Use Survey
Dept. of Agricultural, Food, and Resource Economics
202 Agriculture Hall
East Lansing, MI 48824-1039

«Owner_Name»
«Address»
«City», «State» «Zipcode»

MICHIGAN STATE
UNIVERSITY

Dear «Owner_Name»,

Last week I sent you a survey about bioenergy and your land. **If you have already returned, thank you very much! If not, please do so today. Your opinions matter.**

You are part of a small but representative sample of Michigan landowners to receive this survey. It is very important that you reply so that the results give the clearest possible picture of how future policies can help Michigan landowners.

If you did not receive the survey or need a replacement, please contact me at *swintons@msu.edu* or (517) 353-7218. I hope that you are able to respond.

Sincerely,

Scott M. Swinton
Professor

Figure 17 Second Version of Cover Letter

MICHIGAN STATE
UNIVERSITY

April 27, 2012

«Owner_Name»
«Address»
«City», «State» «Zipcode»

Dear «Owner_Name»,

Last month, I wrote to ask your opinions on bioenergy and your land. As of yesterday I had not yet received your completed survey.

We have undertaken this study to ensure that the design of future bioenergy related policies is informed by the views and concerns of Michigan landowners.

I am writing to you again because each questionnaire really matters for this study. You are one of a small number of people whose opinions we are consulting as part of a research project. By completing this questionnaire you are providing vital information about the potential of U.S. land to grow bioenergy crops.

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

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 refuse to answer certain questions.

I would be most happy to answer any questions you might have. You can contact me by phone at (517) 353-7218, by email at swintons@msu.edu, or by postal mail at Dept. of Agricultural, Food and Resource Economics, 202 Agriculture Hall, Michigan State University, East Lansing, MI 48824-1039.

Spring is approaching. 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 help.

Sincerely,

Scott M. Swinton, Professor

P.S. – If by chance you are not a rural landowner, please answer just the first question and return the questionnaire in its prepaid envelope.

COLLEGE OF
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NATURAL
RESOURCES

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