# The Impact of Biofuels on the Propensity of Land-Use Conversion among Non-Industrial Private Forest Landowners in Florida

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# The Impact of Biofuels on the Propensity of Land-Use Conversion among Non-Industrial Private Forest Landowners in Florida

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**Abstract**

A hypothetical market for renting and converting forested land into row cropping for biofuel production revealed that nearly half of the 1,060 non-industrial landowners sampled in Florida are willing to accept payments for land type conversion and the resulting supply function is inelastic and positive. While respondent's previous involvement with forest management cost-share program increased their probability of accepting payments for forest type conversion, those who indicated forest aesthetics as the primary reason for the land ownership were less likely to participate in this hypothetical market.

**Keywords:** NIPF landowners; Probit regression; Land-use conversion; United States

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## 1. Introduction

The United States (US) imports petroleum for over 60% of its transportation fuels. This high level of reliance on foreign oil has a significant effect on the country national security, economy and international relations (CFR, 2006). Biofuels (ethanol and biodiesel) have the potential to substitute for petroleum; and consequently, reduce the national dependency on imported fossil fuels. Biofuels also provide important environmental benefits, like reducing pollutant emissions and the net additions to atmospheric $CO_2$ (Rahmani and Hodges, 2006). Further contributing to the interest in ethanol, the Energy Policy Act of 2005 mandates the progressive use of renewable fuel in our domestic gasoline supply (Westcott, 2007).

Ethanol is produced from a variety of renewable agricultural products, including corn, wheat, milo, citrus and wastes and forestry residues. In the US, corn is the main input for ethanol production due to its availability and high efficiency in conversion. However, cellulosic-based production of renewable fuels holds some promise in the long term (Puppán, 2002).

The expansion of the ethanol sector will likely have large and important impact on the US agricultural sector. The ethanol industry is intensifying the competition in the corn market, which has the effect of increasing prices for this commodity.[1] Higher demand and price of corn may provide economic incentives to farmers to acquire additional land to increase their production. Since agricultural land is limited, there is a distinct possibility that corn producers will attempt to rent or purchase forested land and convert it to corn production. This type of land-use transition has taken place in the past (see Ramankutty and Foley (1999) for examples), and there is a possibility that it may continue if the prices for corn move higher.

[1] A comprehensive analysis of the impact of ethanol production on the US agricultural sector can be found in Westcott (2007).

In Florida (FL), there is an abundance of land owned by non-industrial private forest landowners (NIPF) that could be rented or purchased by farmers and converted into row cropping of corn. According to the Forest Inventory and Analysis factsheet (Brown and Nowak, 2009), the total forested area in FL is approximately 68,000 $km^2$. About 49% of the state is covered with forests and 94% of the forested land is classified as available for timber production and NIPF owners control 63% of these forested lands in FL.

While there is ample evidence of farmers substituting corn production for soybeans, cotton and other row crops (Westcott, 2007), less is known about their propensity to convert forested land to corn production. This lack of market information generates problems in conducting traditional economic analyses based on a revealed preference framework, where peoples' preferences are revealed by their buying and/or selling habits. To solve this issue, economists have used stated preference (SP) techniques, in which market data are collected directly from individuals using hypothetical or contingent markets. According to Freeman (1993) SP techniques have come to refer to environmental studies in which respondents are asked questions designed to elicit information about their preferences or values. The most common elicitation approach is the contingent valuation (CV) method, a widely used procedure to determine consumer demand for difficult-to-measure non-market goods and services, often times these are environmentally based. With CV, the 'valuation' estimate provided by the respondent's SP to a detailed hypothetical market-for good or service (Carson and Hanemann, 2005). With CV, individuals are asked to state their willingness to pay (WTP) or willingness to accept (WTA) for a specified amount of the non-market good or service through a bidding process.

Although there have been numerous studies involving contingent behavior to elicit WTP and consumer demand, only a few have focused on the supply side analyzing the supplier's

(NIPF owners in this case) WTA and estimating the corresponding hypothetical supply function. This study explains the NIPF owner's acceptance decision regarding land-use conversion with the use of hypothetical corn prices. Their response will help policy makers better understand the influence of corn prices on possible conversion of forest land to row cropping and also it will be useful for understanding the behavior of NIPF owners who may not harvest at prevailing prices, but may participate if the prices reach a level that is acceptable to them.

## 2. Analytical framework

The decision of NIPF landowners to convert forest land into row crop corn production can be estimated by constructing a model integrating forest land ownership, value and use. A model proposed by Alberini et al. (1996) demonstrates that an owner's WTA payment for renting or selling a good will depend upon the owner's expected discounted stream of benefits from that good. In the case of the NIPF owners, they will be comparing the discounted stream of benefits of keeping their land forested *versus* the rent payments owners would receive from making the conversion to corn production.

Within this context, assume $r$ is the price offered to the NIPF owner as payment to convert his/her forested land to corn production. The forest owner will accept the hypothetical contract at offer price $r$ if and only if $r$ is greater than the landowner's WTA, the minimum price they are willing to accept for land conversion, i.e., $r > \text{WTA}$. The influence of variables related to forest land and owner's characteristics in determining the NIPF owner WTA, can be describe using the following joint density function:

$$f\,(r, WTA \;|\mathrm{z}, \mathrm{x}) \qquad (1)$$

where, z is a vector of land or site characteristics and x is a vector of household characteristics including attitudes and management choices.

The probability that an owner will accept payment *r* to convert their forested land to corn can be expressed as the probability that the owner's WTA is less than the offer price *r* or:

$$Pr\ (accept\ payment\ for\ land\ for\ conversion) = Pr\ (r > WTA) \quad (2)$$

The joint density can be expressed as the product of the marginal distribution of WTA and the conditional distribution of the remaining variables:

$$f\,(r, WTA \mid \mathrm{z}, \mathrm{x}) = f\,(r \mid WTA, \mathrm{z}, \mathrm{x})\ f\,(WTA \mid \mathrm{z}, \mathrm{x}) \quad (3)$$

To evaluate the forest owner's participation choices, the dependent variable WTA in equation (3) can be expressed as a dichotomous dependent variable, taking on the value of 1 if the owner accepts *r* and converts to corn production and 0 otherwise.

## 3. Data collection, empirical model and procedure

### *3.1. Data collection*

To elicit the WTA responses by NIPF owners in FL to the prospect of converting their forested land to corn production, primary data were collected using a mail survey. The survey instrument was designed following the Dillman's 'tailored design method' (TDM) (Dillman, 2000) to enhance response rates from survey participants, yield unbiased answers, and minimize measurement error. The TDM is a set of procedures for conducting successful self-administered surveys that produce both high quality information and high response rates (Dillman, 2000).

Care was taken to develop efficient questions and a graphical software was used in the final layout to give the instrument a professional look. The survey was also pretested before being administered to the studied sample of NIPT owners.[2] Names and addresses of NIPF landowners in FL were obtained from the Forest Stewardship Program at the University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS).

A total of 2,832 surveys were mailed to NIPF owners in FL on December 24, 2008, followed by reminder postcards 10 days later. Non-respondents were mailed a second survey in March, 2009 and the survey was concluded after 1,150 surveys were completed and returned. It is important to indicate that 350 surveys were counted as undeliverable. Of the 1,150 returned surveys, 1,060 were completed with no missing relevant data, making the adjusted response rate of 'useable surveys' for this study equal to 42.7%.

### *3.2. Empirical model and estimation procedure*

To evaluate the NIPF landowner's participation choice in the proposed hypothetical market consider the following empirical model:

$$ACCEPT = f\,(BID, HINC, FINC, LAND, TIMBER, NATURE, CSH, CS5, NORTH) + \varepsilon \qquad (4)$$

all the variables are defined in Table 1 and $\varepsilon$ is the error term.

The dependent variable ACCEPT is dichotomous in nature and represents the decision of the landowner to accept or reject a payment *r* to convert forested property to corn production. The offer price *r* is represented by the variable BID and is one of five predetermined prices. Each landowner in the sample was presented, randomly, one of these values as annual payments per

[2] The questionnaire is available by the author upon request.

acre for their land. To help avoid starting point bias, the range of contract offer prices was set to simulate a range in corn prices. Corn productivity (180 bushels per acre) and production costs ($300 per acre) were assumed fixed (North Florida Research and Education Center, 2006). While actual productivity and costs would likely vary from area to area, without knowing parcel level detail these assumptions will serve to build a hypothetical market. Potential revenues were then determined for corn prices ranging from $3.66 to $8.27 per bushel in five increments. Revenues less production costs were then considered available as annual rent per acre payments to forest owners and assigned as: $360, $480, $740, $980, and $1,190. The rest of the independent variables control for the main characteristics affecting NIPF owners' decision; i.e., landowner attitude and managerial strategies, land characteristics, and participation in assistance programs. Table 1 describes all the variables included in the empirical analysis.

Due to the binary nature of the dependent variable (ACCEPT) a Probit regression is used to estimate equation (4). Specifically, the model is assumed to take the form:

$$Pr(Y=1|\, x) = \Phi(x'\beta) \qquad (5)$$

where *Pr* denotes probability, $\Phi$ is the cumulative distribution function of the standard normal distribution, $x$ is the vector of independent variables and $\beta$ is the vector of unknown parameters. Estimates for the unknown parameters are obtained using maximum likelihood (ML) estimation (Greene, 2003).

## 4. Results and discussions

Table 2 presents the percentage of landowners willing to accept payments to rent their woodlands for land-use conversion at each of the five offered prices (BID). For most of the sample, the rate of acceptance increases with the offer price. However, when the bid increases from $360 to $480 there is a slight but non-significant drop in the acceptance rate. The data also shows a significant drop of approximately 8% when the bid increases from $980 to $1,190. It is worth noticing that this kind of behavior has been reported in the literature (Kennedy, 2001; Shyamsundar and Kramer, 1996).

Shyamsundar and Kramer (1996) argue that the slight drop in the acceptance level with increased bids could be explained as a random event. However, there may be additional reasons to explain the drop in the acceptance rate when bid increased from $980 to $1,190. Table 3 shows the main reason given by the respondents when asked why they did not accepted the offered price. As it is shown, the group of landowners who were offered $1,190 appears to have a higher degree of concern about the environment than the other groups. In comparison, this group has a high proportion of landowners who are opposed to converting their land at any price, and they ranked their reasons for land ownership, such as valuing beauty higher than other groups. This may in point explain the decline in bid acceptance. The importance of preserving land in its forested condition by landowners is also reported by Kennedy (2001). This author indicates that in Virginia, NIPF owners with high environmental preferences are generally less likely to accept bids even with increases in offered prices. Additionally, a higher proportion of respondents at the higher bid level indicated that they do not believe the hypothetical market for corn production would work. Perhaps, the landowners may doubt price was offered, since $1,190 was too high for this specific market and this contributed to their skepticism. It is important to indicate that, while the $1,190 group indicated a difference in their level of environmental concern, the initial sample was randomized and it is unlikely that any group would be inherently biased from the others.

The data in Table 2 is use to plot a supply curve (Figure 1) which describes, *ceteris paribus*, the NIPF landowners' WTA a bid at any given price. The supply curve follows a positive trend and depicts a steep slope, suggesting an inelastic behavior. Binkley (1993) explains that woodlands display, in general, inelasticity supplies curves because of the substantial capital and time invested in this sector to operate. On the other hand, the trend of the supply curve shows an R-square equal to 0.711 indicating that the offered price explains 71.1% of the acceptance rate. A more refined analysis of factors affecting the NIPF landowners' likelihood of accepting the offered bid is presented in Table 4.

Table 4 shows the ML estimates of the Probit model that specify the probability a landowner accepts a bid as a function of the offer price, landowner attitude and managerial strategies, land characteristics, and participation in assistance programs. This table displays the estimated coefficients along with their respective marginal effects (MEs). The MEs measure the change in the probability of WTA due to a one unit change of a specific explanatory variable. The MEs for the dummy variables are estimated by taking the difference between the value of the prediction when the exogenous variable equals 1 and when it equals 0. By contrast, the MEs for the continuous variables are estimated as $\mathrm{ME} = \phi(\delta \mathrm{Z})\delta$, where $\phi$ is the probability density function, $Z$ is the vector of exogenous variables and $\delta$ are the estimated parameters (Madalla, 1983). The MEs for both kinds of variables are measured at the mean value of the regressors.

As shown in Table 4, the Probit model performs well in explaining variations in responses to the contingent valuation question. More precisely, the model correctly predicts landowners' decisions to convert their land at the offered price for 51.0% of the observations and the likelihood ratio test rejects the null hypothesis that all slope coefficients are equal to zero at the 1% level. Individually, 9 out of the 10 estimated parameters are statistically different from zero and most of them present signs consistent with the literature and intuitive expectations.

The main results of the Probit model can be summarized as follows. The variable BID displays a positive and significant effect in determining the acceptance level for land-use conversion. This result agrees with the economic theory and indicates that NIPF landowners in FL are rational decision-makers. In addition, the ME for this variable is small in magnitude, confirming the finding described earlier that woodlands display an inelastic price elasticity of supply. Similar results were reported by Shyamsundar and Kramer (1996).

The annual household income (HINC), which includes woodland and non-woodland earnings, displays a positive and statistically significant coefficient. This outcome suggests that landowners with higher annual incomes are more likely to accept the offered bid than those earning less income. This result is consistent with the finding of Joshi and Arano (2009) who suggest that as income level increases, the capacity of the landowners to acquire resources (i.e., tract size, information and private consultation) increases allowing them to engage in those forest management activities which will maximize their profits. However, contradictory findings were reported by Kennedy (2001) who indicates that in Virginia wealthier landowners tend to hold their woodlands as long-term investments.

The variable FINC evaluates the effect of forest-based income on the probability that the respondent would accept the offered price. To avoid any collinearity problems with HINC, this variable was measure as a categorical variable reflecting the importance of forest-based income on the total income. FINC also displays a positive and significant relationship with the WTA the offered bid. This result could be explained by the fact that landowners with higher percentage of their income coming from their woodland are more business oriented, and more willing to accept the notion of hypothetical markets and transforming their forest into a different use. Conversely, landowners with lower percentage of their income coming from their woodlands could be holding their properties for non-economic (environmental) reasons or as a long-term investment and less likely to willingly convert their forests.

Land size (LAND) presents a positive but not statistical effect on the NIPF landowners' WTA the offered bid. It is important to indicate that mixed results have been found in the literature with respect to effect of the parcel size on the NIPF landowners' forest management behavior. On the one hand, Amacher et al. (2003) reported land size as the single most important variable in explaining the landowner managerial behavior. However, Joshi and Arano (2009) found that the forest size has negative effects on landowners' willingness to engage in silvicultural activities. No significant effects were reported by Romm et al. (1987).

The variable TIMBER is positive and significant suggesting that landowners managing their woodlands for timber production are more likely to rent out their woodland than non-timber oriented landowners. In fact, the ME for TIMBER indicates that the former group is 20.8% more likely to accept the offered price than the later group. This result agrees with Egan (1997) and Conway (2002). Conway (2002) shows that landowners who were heavily involved in non-timber activities are very reluctant in accepting any kind of compensation for harvesting their woodlands.

The variable NATURE is negative and significant revealing an inverse relationship between the probability of participating in the program and owning the forest for its amenities (recreation, wildlife, environment, etc.). Joshi and Arano (2009) show that owning forestland for non-timber forest products and environmental services are becoming very popular, especially in areas where population density is high. In fact, Hodge and Southerland (1992) claimed that the main reasons why NIPF landowners owned forestland in Virginia were to preserve nature, maintain scenic beauty and for viewing wildlife. On the other hand, Zhang et al. (2005) argue that when a landowner makes frequent use of non-timber products and services, owning forestland is more efficient for them because it saves the transaction costs involved in getting these services from the market.

The variables CSH and CS5 analyze the behavior of landowners involved in any state or federally sponsored cost share programs (CSP) for more and less than five years, respectively. CSH show a positive and significant coefficient and a ME of 0.221 suggesting that landowners using CSP for more than five years are 22.1% more like to accept a bid than their counterparts. Demers (2010) verifies this and states that agricultural farmers have a history of using CSP to obtain additional governmental payments for their land. If the offered bid to keep the land out of production exceeds what owner is receiving from the government, then making the switch back to an agricultural commodity will become more economically attractive.

Conversely, NIPF landowners involved in CSP for less than five years (CS5) show a negative and significant preference towards accepting the bid. This result shows a significant change with respect to NIPF owners involved in CSP for over five years. This behavioral change could be explained by changes in the type of NIPF owner seeking involvement with CSP in FL. According to Demers (2010), in recent years NIPF landowners owning non-commercial forests have join the CSP, mostly to engage the wildlife habitat improvements program (WHIP). WHIP is a voluntary program for conservation-minded landowners who want to develop and improve wildlife habitat. A similar trend is reported by Joshi and Arano (2009) among NIPF landowners in West Virginia. In this case, the offered price is irrelevant to landowners since land profitability falls outside of their objectives.

Lastly, the dummy variable NORTH evaluates potential differences in the WTA among woodlands located in north and south Florida. This variable present a positive and significant coefficient and its ME suggests that landowners owing land in north Florida are 17.8% more likely to accept the contract than those who own woodlands in the south. This result could be explained by the fact that south Florida presents a higher urban population than north Florida. Thus, land owner in the south could be holding their land for non-production proposes like real estate development.

## 5. Conclusions

This study evaluates the propensity of non-industrial private forest (NIPF) landowners to rent their forested land to cultivate corn for biofuel production. A contingent valuation approach is used to estimate the forest owner's willingness to accept payments under alternative rent values, derived from hypothetical corn price scenarios. The empirical analysis uses data collected from 1,060 NIPF landowners in Florida. The results shows that 45.8% of the studied NIPF landowners are willing to accept payment to rent their land and the overall supply function is positive and inelastic. NIPF landowners managing their woodlands for timber and those using any state or federally sponsored cost share programs have the highest probability of accepting payments. Opposite results are found for those owning their forest for beauty, hunting or other recreational activities. Regional differences are also demonstrated with NIPF landowners in north Florida more likely to rent their land than those in central and south Florida.

**Table 1. Variable Definition and Descriptive Statistics**

| Variable | Type | Definition | Mean | Std. Dev. |
|---|---|---|---|---|
| ACCEPT | *Dummy* | Dependent variable equals to 1 if the landowner to accept the BID; 0 otherwise | *0.45* | -- |
| BID | *Continuous* | Offered price per acre per year in US Dollars | 755.38 | 314.36 |
| HINC | *Ordinal* | Annual household income.<br>1 = ≤$25,000<br>2 = $25,000-$49,000<br>3 = $50,000-$99,000<br>4 = $100,000-$199,000<br>5 = ≥$200,000 | 3.19 | 1.12 |
| FINC | *Categorical* | Importance of forest based income: 1= unimportant to 5 = very important | 1.88 | 1.15 |
| LAND | *Continuous* | Total acres of forestland owned | 490.54 | 1906.72 |
| TIMBER | *Dummy* | 1 if manage forest for timber production; 0 otherwise | 0.83 | -- |
| NATURE | *Categorical* | Relative importance of forest beauty, protecting nature, hunting or fishing. 1= unimportant to 5 = very important | 3.849 | 0.85 |
| CSH | *Dummy* | 1 if ever participated in a cost share program; 0 otherwise | 0.57 | -- |
| CS5 | *Dummy* | 1 if participated in the cost share program in the past 5 years; 0 otherwise | 0.52 | -- |
| NORTH | *Dummy* | 1 if site is located in north Florida; 0 otherwise | 0.91 | -- |

**Table 2. WTA Payments per Offered Price**

| Offered Price | % of Acceptance | N |
|---|---|---|
| **360** | 40.3% | 226 |
| **480** | 40.2% | 209 |
| **740** | 49.7% | 193 |
| **980** | 53.9% | 204 |
| **1,190** | 45.6% | 228 |
| ***Total*** | *45.8%* | *1,060* |

**Table 3. Reasons respondents gave for not accepting hypothetical contract at different offered prices**

| Offered Price | The price is to low | Don't believe this program would work | Will never convert forest property | Other reasons* |
|---|---|---|---|---|
| **360** | 15.0% | 17.0% | 65.2% | 16.5% |
| **480** | 16.0% | 12.7% | 60.8% | 14.5% |
| **740** | 9.2% | 12.9% | 67.3% | 17.8% |
| **980** | 11.4% | 17.0% | 67.0% | 16.0% |
| **1190** | 1.9% | 22.8% | 72.7% | 19.8% |
| ***Total*** | *10.9%* | *17.1%* | *66.1%* | *16.9%* |

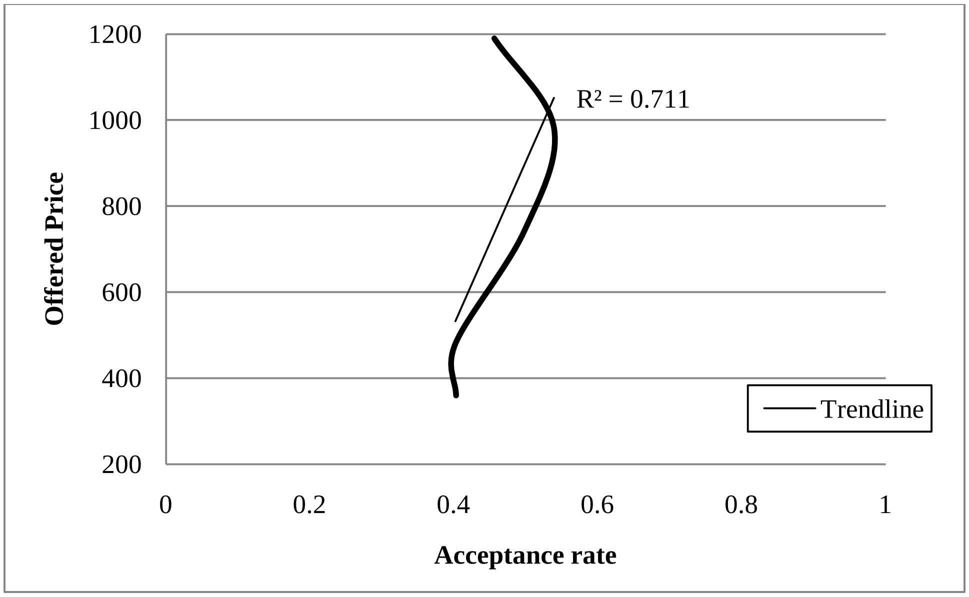
*Other reasons include environmental issues like high value of forest beauty, protecting nature, and interest in hunting or fishing.

**Table 4. Determinants of WTA (Probit Model)**

| Variable | Coefficient | SE | ME |
|---|---|---|---|
| **CONSTANT** | -1.4262*** | 0.4187 | -- |
| **PRICE** | 0.0003* | 0.0001 | 0.0001 |
| **TINCOME** | 0.1527*** | 0.0512 | 0.0609 |
| **FINCOME** | 0.1126** | 0.0515 | 0.0449 |
| **LAND** | 0.0000 | 0.0000 | 0.0000 |
| **TIMBER** | 0.5376*** | 0.1816 | 0.2089 |
| **NATURE** | -0.1824*** | 0.0662 | -0.0727 |
| **CSH** | 0.5712*** | 0.1723 | 0.2219 |
| **CS5** | -0.2849** | 0.1249 | -0.1132 |
| **NORTH** | 0.4582** | 0.2193 | 0.1787 |
| ***Likelihood Ratio Test ($\chi^2$[9])*** | ***62.96**** | | |
| ***% of Correct Predictions*** | ***51.05%*** | | |

* 10%, ** 5% and ***1% level of significance.
**NOTE**: The dependent dichotomous variable reflects the level of acceptance.

**Figure 1. Supply curve**



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