Journal of Agricultural and Applied Economics, 42,1(February 2010):105–119

Farmer Willingness to Supply Poultry Litter for Energy Conversion and to Invest in an Energy Conversion Cooperative

Kimberly L. Jensen, Roland K. Roberts, Ernie Bazen, R. Jamey Menard, and Burton C. English*

Conversion of poultry litter to energy can serve as a renewable energy source and provide an alternative to land application in areas where poultry production is intensive. Economies of size may limit a farmer's ability to economically use on-farm conversion. Capital costs can be spread across several poultry farmers to convert poultry litter to energy in a centralized facility. This research determined influences on the amount of litter poultry producers will to sell to a centralized conversion facility, on their willingness to invest in a conversion cooperative, and on the prices for litter required to divert litter from current uses.

Key Words: poultry litter, supply, renewable energy

JEL Classifications: Q12, Q13

Increases in energy costs, with energy costs comprising over half of cash expenses for poultry producers (Cunningham, 2008), coupled with a desire for sustainable production practices, highlight the need to investigate the use of poultry litter as a potential energy feedstock. Poultry litter, the bedding and waste materials removed from poultry houses, can serve as an energy feedstock for heating and electricity generation either in on-farm systems or in centralized litter-to-energy conversion facilities. Conversion of poultry litter to energy can have two primary environmental benefits. First, electricity produced from poultry litter is considered renewable energy. The U.S. Department of Energy (DOE) includes bioenergy, or energy from biomass, as a source of renewable energy and includes animal wastes in its definition of biomass that can be used to generate renewable energy (DOE, 2009). Second, conversion of litter to electricity can provide an alternative use for the litter in areas where poultry production is intensive and litter supplies exceed the fertilizer needs on nearby farmlands. While litter can serve as an inexpensive fertilizer, when the poultry litter is applied to meet nitrogen needs, excess phosphorus can build up at the soil surface, potentially causing eutrophication of the water supply (Howry et al., 2008). Hence, in some areas of intensive poultry production, new uses other than land application may be environmentally beneficial.

On-farm energy systems have appeal in that they use litter from the farm to supply electricity back to the farm directly or to sell onto

Kimberly L. Jensen and Roland K. Roberts are professors, Ernie Bazen is assistant professor, R. Jamey Menard is research associate, and Burton C. English is professor, Department of Agricultural Economics, The University of Tennessee.

This study was funded in part by a grant from Tennessee Department of Agriculture.

the grid, but these systems require investment of dollars, labor, and management by poultry operators. Furthermore, because litter may be applied as fertilizer, sold to litter handlers/ farmers to be applied on nearby farms, or used in trade for poultry house cleaning, the value in energy production must be sufficient to draw litter from these current uses.

Poultry houses are typically cleaned out once or twice per year. About 75% of the producers in this study cleaned their houses out once or twice per year. Potential poultry litter handling costs include cleanout of the houses, transport to another location if the litter is sold and transportation is provided, and application costs either to the farmer's own land or another farmer's land. Among Tennessee poultry producers investigated in this study, about 48% of the litter was used on-farm, about 15% was used in trade for poultry house cleaning services, and just less than 37% was sold. Of the on-farm use, over 68% was applied as fertilizer to hay/grassland. Skid steer loaders and dump trucks are used for collecting and transporting litter, while manure spreaders are used in land application. Most farmers in this study either cleaned out their own poultry houses or used a cleanout service which accepted litter in return for the cleanout service, while only a few paid a fee for cleanout services. Among those who had paid a fee for cleanout, the average fee was about \$1,266 per house or about \$7.42 per ton ($n = 18$). The benefit of applying litter to the farmer's own land is that litter is an inexpensive source of fertilizer, often used to improve pastureland. As part of the survey, farmers were asked how much litter they land applied as well as estimates of the tons per acre of nitrogen, P_20_5 (phosphorus), and K_20 (potassium) fertilizer that were replaced. The average values per ton of litter as fertilizer, as estimated by the farmers, were about 78 pounds of nitrogen, 48 pounds of P_20_5 (phosphorus), and 44 pounds of K_20 (potassium) per ton of litter. Based on current market prices at the time of the survey, the estimated value of a ton of litter as fertilizer was about \$49 per ton.

Economies of size required for cost effective energy conversion may limit an individual farmer's ability to economically use on-farm energy conversion of poultry litter. Capital costs of energy conversion, however, can be spread across several poultry farmers to convert poultry litter to energy in a centralized energy facility (Bachewe et al., 2008). Central anaerobic digesters, for example, can process a variety of wastes, including food processing wastes, dairy manure, swine manure, in addition to poultry litter. Larger scale gasification facilities can be used in high density areas of broiler litter production (Flora and Riahi-Nezhad, 2006). Numerous state and federal resources, such as grants, low interest loans, and tax credits, exist for conversion of litter to energy (EPA, 2009). A poultry litter to energy conversion facility could provide poultry producers with an alternative market for their farms' poultry litter. Furthermore, if producers invest in a cooperative that converts litter to energy, producers could benefit from an additional market for their poultry litter, as well as income potential from electricity sales from the conversion facility.

The objective of this research was to determine the factors influencing the amount of litter Tennessee poultry producers are willing to sell to a centralized energy conversion facility, the dollar amount they believe they would require to sell the poultry litter into the facility, and their willingness to invest in a cooperative that converts litter and other wastes to energy. Data to model these three decisions are from a 2008 survey of Tennessee poultry producers.

Previous Studies

Several recent studies have examined issues of land application and composting of litter (Armstrong, Goodwin, and Hamm, 2007; Carreira et al., 2007; Howry et al., 2008; Kemper, Goodwin, and Mozaffari, 2008). Other studies have examined feasibility of central digesters (Lewis, 2001; Kubsch, 2003; Myers and Deisinger, 2006; Je et al., 1998). Goan et al. (2002) evaluated the disposition of poultry litter. Two studies have focused specifically on the feasibility of using poultry litter in energy conversion. Whittington (2007) examined availability of poultry litter for energy feedstock but did not incorporate costs of handling, revenues, or costs for conversion. Flora and Riahi-Nezhad

(2006) conducted a feasibility study of using litter for energy purposes in South Carolina. They employed facility scales of 1,000 tons of litter per year for an on-farm facility (50–70 kW capacity), 10,000 tons per year for a community-scale facility (500–700 kW capacity), and 50,000 tons per year for a regional-scale facility (2.5–3.5 MW capacity). Another study examined using large-scale gasification facilities, such as 55 MW using 700,000 tons of litter per year (LaCapra Associates, 2006). While several studies have examined feasibility of energy conversion using animal wastes, including poultry litter, none has examined factors influencing farmers' willingness to supply litter for alternative energy systems, pricing of litter, nor their willingness to invest in energy cooperatives to convert waste to energy.

Numerous studies have examined demographics of cooperative members compared with nonmembers. Wachenheim, deHillerin, and Dumler (2001) studied producer perceptions of hog marketing cooperatives. They found that, compared with cooperative members, independent producers tended to be older, less educated, and market a lower number of hogs. Black (1985) had similar findings regarding farm size, with results indicating that farmers and ranchers who were cooperative members owned or leased more land than independent producers. Bravo-Ureta and Lee (1988) found that dairy cooperative members were more likely to have Extension Service contacts and operate smaller dairies than independent producers. Stofferahn (2004) examined demographics and farm characteristics across willingness to share labor and machinery, and found that farmers who were willing to share rented more land, had more education, were slightly older, and were more likely to already be members of cooperatives than those farmers who were not willing to share. Puaha (2003) evaluated determinants of investment in a value-added wheat products New Generation Cooperative. Results from the study indicated that those who were members had planted more wheat, had higher education levels, were younger, and had a higher share of income from wheat than those who were not members. These studies indicate interest among researchers and others in knowing the determinants of willingness to participate in farmer cooperatives in general, and more specifically potential interest in an energy conversion cooperative that uses poultry litter as a feedstock.

Carreira, Goodwin, and Hamm (2006) investigated the value of litter to farmers who might potentially purchase litter to land apply on their farms. Among those who had previously purchased poultry litter, they found that the purchase price for broiler litter averaged $26 per ton. They found that some of the impediments to farmers using litter were that the litter was not available when needed, they did not have much experience using poultry litter, they did not have proper equipment to use litter, and that land application is very time consuming.

Data and Methods

A mail survey of Tennessee poultry producers was conducted to obtain information for this study. The survey was mailed in September 2008 to 499 poultry producers who, according to National Agricultural Statistical Service (NASS), had at least one poultry house in Tennessee. A total of 122 producers responded for a 24.5% response rate. The survey contained questions about farm characteristics, such as farm income, acres farmed, litter production, and litter disposition. It also contained questions regarding farmer demographics, such as farmer age, education level, and membership in organizations. Included in the survey were questions regarding willingness to supply litter to a central energy conversion facility, dollars per ton that producers stated they would require for the poultry litter to sell it into a conversion facility, and willingness to invest in an energy conversion cooperative that would use litter as a feedstock. To obtain information about willingness to supply litter to a conversion facility, farmers were first asked whether they would be willing to sell a portion of their operation's poultry litter for energy conversion in a centralized energy project. If they indicated they would sell some, they were asked how many tons per year they could commit. They were then also asked what price they would need for the litter if the centralized facility arranged for litter to be picked up at the farm. If they would exchange the litter for hauling, they were asked to indicate a price of \$0.

Amount of Litter Willing to Sell to an Energy Conversion Facility

The amount of litter farmers would be willing to sell to a central energy conversion facility can be represented as:

$$\text{(1)}\quad \begin{aligned} &STONSLIT = f(TONSLIT, ACFARMED, SELLIT, \\ &GIVELIT, PASTFERT, BROILERS, SKIDSTEER, \\ &SPREADER, DUMP, FULLOWN, FINC10K, \\ &FINC1025K, FINC2550K, PCTOFI, DEBT020, \\ &DEBT2070, AGEGT65, COLLGRAD, COOP), \end{aligned}$$

where *STONSLIT* is the tons of litter a farmer would be willing to sell to a centralized energy project per year. The explanatory variables are provided in Table 1, along with their definitions and hypothesized relationships with *STONSLIT*.

Those who produce more litter than others (*TONSLIT)* are expected to be willing to sell larger amounts of litter to a central facility each year. Acres farmed (*ACFARMED*) is hypothesized to have a negative influence on willingness to sell, because application on one's own land would compete with off-farm sales. If farmers are already selling litter off-farm (*SELLIT*), they are expected to be willing to sell more into a centralized energy project. If farmers are giving away some or all of their litter (*GIVELIT*), they are expected to be willing to sell more into a centralized energy project. If farmers are land applying some or all of their litter on pasture (*PASTFERT*), they are expected to be willing to sell less into a centralized energy project. While the effect of broiler production (*BROILERS*) cannot be hypothesized *a priori*, this variable is included to evaluate the effects of poultry-operation type on the amount of litter producers would sell. Ownership of a skid steer loader (*STEERSKID*) and a dump truck (*DUMP*) are hypothesized to have positive influences because this equipment can be used to move litter, while ownership of a spreader truck (*SPREADER*) is hypothesized to have a negative influence, because the spreader can be used for on-farm land application.

Producers who are full owners (*FULLOWN*) are hypothesized to have greater influence over decisions regarding disposition of poultry litter and are hypothesized to be more willing and able to sell litter to a central facility. Farmers with greater farm income are hypothesized to be willing to sell more, because they may be more willing and able to seek out new markets for the litter. Hence, the signs on 2007 net farm income of less than \$10,000 (*FINC10K*), farm income of \$10,000 to \$24,999 (*FINC1025K*), and farm income of \$25,000 to \$49,999 (*FINC2550K*) are anticipated to be negative, since these categories are being compared with farm incomes of \$50,000 or greater. The percentage of income from off-farm sources (*PCTOFI*) is expected to have a positive influence, because a larger percentage of income earned off-farm may reflect farmers' willingness to obtain income from multiple sources. Farmers with more debt may be less willing to take the risk of entering a new market for litter than those with less debt. Consequently, those with higher debt are expected to be willing to sell less litter and those with lower debt are hypothesized to be willing to sell more litter to a conversion facility. The signs on the estimated coefficients for debt-to-asset of 20% to 69.99% (*DEBT2070*) and debt-to-asset of at least 70% (*DEBT70*) are hypothesized to be negative.

Younger and more highly educated (*COLLGRAD*) farmers are hypothesized to be willing to sell more litter into an energy conversion project than older (*AGEGT65*) or less educated farmers. Membership in cooperatives (*COOP*) is hypothesized to have a positive influence.

The Tobit model is used to estimate Equation (1), because 33% of producers said they would not be willing to sell litter to an energy conversion facility. The Tobit model can be represented as (Greene, 2008):

$$\text{(2)}\quad STONSLIT_i = \begin{cases} STONSLIT_i \text{ if } y_i^* > 0 \\ 0 \text{ if } y_i^* \leq 0 \end{cases},$$

where $STONSLIT_i$ is the tons of litter the *ith* producer would be willing to sell into an energy

Table 1. Variable Names, Hypothesized Signs and Definitions

Variable Name	Eq. 1 Sign	Eq. 5 Sign	Eq. 8 Sign	Definition
		Dependent Variables		
STONSLIT	NA[a]	NA	NA	Tons of litter would sell to a centralized energy facility per year
INVCOOP	NA	NA	NA	1 if willing to invest in an energy cooperative, 0 otherwise
PLIT	NA	NA	NA	0 if price required is $0 to $14.99 per ton, 1 if price required is $15.00 to $24.99 per ton, 2 if price required is $25.00 per ton or greater
		Explanatory Variables		
TONSLIT	+	+	−	Tons of litter produced on-farm annually
ACFARMED	−	−	+	Acres farmed
SELLIT	+	+	+	1 if currently sell some litter, 0 otherwise
GIVELIT	+	+	−	1 if currently give some litter away, 0 otherwise
PASTFERT	−	−	+	1 if currently apply some litter as fertilizer for pasture, 0 otherwise
BROILERS	+ or −	+ or −	+ or −	1 if have broilers, 0 otherwise
SKIDSTEER	+	NA	NA	1 if own a skid steer loader, 0 otherwise
SPREADER	−	NA	NA	1 if own a spreader truck, 0 otherwise
DUMP	+	NA	NA	1 if own a dump truck, 0 otherwise
FULLOWN	+	+	NA	1 if full owner (sole proprietor), 0 otherwise
FINC10K	−	−	+	1 if 2007 net farm income less than $10,000, 0 otherwise
FINC1025K	−	−	+	1 if 2007 net farm income at least $10,000 but less than $25,000, 0 otherwise
FINC2550K	−	−	+	1 if 2007 net farm income at least $25,000 but less than $50,000, 0 otherwise
FINC50K	NA	NA	NA	1 if 2007 net farm income greater than or equal to $50,000, 0 otherwise (omitted dummy category)
PCTOFI	+	+ or −	−	Percent of 2007 household income (before taxes) from off-farm sources
DEBT020	NA	NA	NA	1 if debt-to-asset ratio is less than 20%, 0 otherwise (omitted dummy category)
DEBT2070	−	−	+	1 if debt-to-asset ratio is 20% to 69.99%, 0 otherwise
DEBT70	−	−	+	1 if debt-to-asset ratio is at least 70%, 0 otherwise
AGEGT65	−	−	NA	1 if farmer age is greater than 65, 0 otherwise
COLLGRAD	+	+	NA	1 if college graduate, 0 otherwise
COOP	+	+	+	1 if cooperative member, 0 otherwise
ECOST	NA	+	NA	1 if energy costs per square foot are less than $0.25, 2 if energy costs per square foot are at least $0.25 but less than $0.50, 3 if energy costs per square foot are at least $0.50 but less than $0.75, 4 if energy costs per square foot are at least $0.75

[a] NA signifies Not Applicable.

conversion facility, $y_i^* = \boldsymbol{\beta}'\mathbf{x_i} + \varepsilon_i$ is a latent variable and $\mathbf{x_i}$ is a vector of explanatory variables for the *ith* farmer. The expected value of $STONSLIT_i$ is:

$$E[STONSLIT_i|\mathbf{x_i}] = \Phi(\boldsymbol{\beta}'\mathbf{x_i}/\sigma) \times \left\{\boldsymbol{\beta}'\mathbf{x_i} + \sigma\frac{\phi(\boldsymbol{\beta}'\mathbf{x_i}/\sigma)}{\Phi(\boldsymbol{\beta}'\mathbf{x_i}/\sigma)}\right\}, \tag{3}$$

where Φ is the standard normal cumulative distribution function and ϕ is the cumulative density function of the standard normal distribution (Greene, 2008).

An explanatory variable's marginal effect is an estimate of a change in tons for a change in the explanatory variable. The marginal effect for the jth continuous variable is calculated as:

$$\frac{\partial E(STONSLIT_i|\mathbf{x_i})}{\partial \mathbf{x_{ji}}} = \Phi\left(\frac{\boldsymbol{\beta}'\mathbf{x_i}}{\sigma}\right)\boldsymbol{\beta}_\mathbf{j}. \tag{4}$$

The marginal effect for continuous variables may be calculated at the sample means of the explanatory variables. The marginal effect for a dummy explanatory variable is found by calculating the expected value of $STONSLIT_i$ with the dummy variable held at 1 and then at 0 with all other variables held at their means, then taking the difference between these two values.

Willingness to Invest in an Energy Cooperative

Farmers' willingness to invest in an energy cooperative can be represented as:

$$INVCOOP = f(TONSLIT, ACFARMED, SELLIT, GIVELIT, PASTFERT, BROILERS, FULLOWN, FINC10K, FINC1025K, FINC2550K, PCTOFI, DEBT020, DEBT2070, AGEGT65, COLLGRAD, COOP, ECOST), \tag{5}$$

where all variables are presented in Table 1, along with their definitions and hypothesized effects.

Tons of litter produced (*TONSLIT*) is hypothesized to have a positive influence, since an energy cooperative would provide an additional market for litter. Acres farmed (*ACFARMED*) is hypothesized to have a negative influence, since more land means greater opportunity to land apply the litter. Farmers who currently sell litter off-farm (*SELLIT*) are expected to be more willing to invest in an energy cooperative as are farmers who give litter away (*GIVELIT*). Using litter as fertilizer on pasture (*PASTFERT*) is hypothesized to carry a negative sign. The broilers variable (*BROILER*) is included to measure the effect of operation type; however, the sign on *BROILER* cannot be postulated *a priori*. Full ownership (*FULLOWN*) is hypothesized to have a positive influence, because full owners might be more likely to have more autonomous decision-making ability on the investment decision.

Farmers with higher farm incomes are hypothesized to be more likely to be willing to invest in an energy conversion cooperative, therefore the dummy variables *FINC10K*, *FINC1025K*, and *FINC2550K* are postulated to carry negative signs. The sign on share of income from off-farm sources could not be hypothesized *a priori*. Investment in a new cooperative might be seen as more risky and with more uncertain returns compared with off-farm income. A counterargument is that willingness to invest could increase with a greater share of off-farm income, because the off-farm income might provide the farmer with additional income that could protect them from unexpected losses from farming. Farmers with higher debt are hypothesized to be less likely to be willing to invest in an energy conversion cooperative than farmers with less debt. Hence the signs on the debt-to-asset ratio dummy variables *DEBT2070* and *DEBT70* are hypothesized to be negative.

Farmers at or near retirement (*AGEGT65*) are hypothesized to be less likely to be willing to invest in an energy cooperative. More educated farmers (*COLLGRAD*) are postulated to be more likely to be willing to invest in an energy conversion cooperative. A farmer who is already a member of a cooperative (*COOP*) is expected to be more likely to be willing to invest. Farmers with higher energy costs (propane and electricity) per square foot of poultry housing space (*ECOST*) are hypothesized to be more willing to invest in an electricity conversion cooperative.

The Probit model is used to estimate Equation (5), since willingness to invest in an energy cooperative is a categorical variable.

The probability of willingness to invest in an energy cooperative can be represented as:

$$(6) \quad \Pr(INVCOOP_i = 1) = \Phi(\boldsymbol{\beta}'\mathbf{x_i}),$$

where $INVCOOP_i$ is the variable representing whether the *ith* farmer would be willing to invest in an energy conversion cooperative (1 if 'Yes', 0 if 'No'), Φ is the standard normal cumulative distribution function, and $\mathbf{x_i}$ is vector of explanatory variables for the *ith* farmer.

To calculate the change in probability of willingness to invest with a change in the *jth* continuous variable for the *ith* farmer, the marginal effect is calculated as:

$$(7) \quad ME_{ji} = \frac{\partial \Pr(INVCOOP_i = 1)}{\partial \mathbf{x_{ji}}} = \phi(\boldsymbol{\beta}'\mathbf{x_i})\boldsymbol{\beta_j},$$

where ϕ is the cumulative density function of the standard normal distribution. The marginal effect for a continuous variable may be calculated at the sample means of the explanatory variables. For a dummy explanatory variable, the marginal effect is found by calculating the probability with the dummy variable held at 1 and then at 0, with all other variables held at their means, then taking the difference between these two probabilities.

Pricing of Litter to be Sold

The price that farmers stated they would need for litter to be sold into a conversion facility can be represented as:

$$(8) \quad \begin{aligned} &PLIT = f(TONSLIT, ACFARMED, SELLIT,\\ &GIVELIT, PASTFERT, BROILERS, FINC10K,\\ &FINC1025K, FINC2550K, PCTOFI, DEBT020,\\ &DEBT2070, COOP), \end{aligned}$$

where all variables are presented in Table 1, along with their definitions and hypothesized effects.

Tons of litter produced (*TONSLIT*) is hypothesized to have a negative influence on price needed, while acres farmed (*ACFARMED*) is hypothesized to have a positive influence. Farmers who currently sell litter off-farm (*SELLIT*) are anticipated to require a higher price per ton, since they already have a market for their litter. Giving away litter is postulated to have a negative influence on price needed (*GIVELIT*). Using litter as fertilizer on pasture (*PASTFERT*) is hypothesized to carry a positive sign, since it represents an alternative use for the litter. The broilers variable (*BROILER*) is included to measure the effect of operation type; however, the sign on *BROILER* cannot be postulated *a priori*.

Farmers with higher farm incomes are hypothesized to be more willing to accept a lower price for the poultry litter, and therefore the signs on the variables *FINC10K*, *FINC1025K*, and *FINC2550K* are postulated to carry positive signs. A greater share of income from off-farm sources (*PCTOFI*) is hypothesized to have a negative influence, as farmers with more reliance on off-farm income sources may be willing to accept a lower price for their litter. Farmers with higher debt are hypothesized to require a higher price for their litter than those with less debt. Hence the signs on the debt-to-asset ratio dummy variables *DEBT020* and *DEBT2070* are hypothesized to be positive. A farmer who is a member of a cooperative (*COOP*) is anticipated to state that they would need a higher price for the litter.

An ordered Probit model is used to estimate Equation (8), since the pricing variable is an ordered categorical variable. The probability of stating a particular pricing category for litter can be represented as:

$$(9) \quad \begin{aligned} &\Pr(PLIT_i = 0) = \Phi(-\boldsymbol{\beta}'\mathbf{x_i}),\\ &\Pr(PLIT_i = 1) = \Phi(\mu - \boldsymbol{\beta}'\mathbf{x_i}) - \Phi(-\boldsymbol{\beta}'\mathbf{x_i}), \text{ and}\\ &\Pr(PLIT_i = 2) = 1 - \Phi(\mu - \boldsymbol{\beta}'\mathbf{x_i}), \end{aligned}$$

where $PLIT_i$ is the variable representing the price level that the *ith* farmer stated they would need to sell their litter into an energy conversion facility if the litter were picked up at their farm (0 if price required is \$0 to \$14.99 per ton, 1 if price required is \$15.00 to \$24.99 per ton, 2 if price required is \$25.00 per ton or greater), Φ is the standard normal cumulative distribution function, and $\mathbf{x_i}$ is vector of explanatory variables for the ith farmer.

To calculate the change in probability of willingness to invest with change in the *jth* continuous variable for the ith farmer, the marginal effect is calculated as:

$$\frac{\partial \Pr(PLIT_i=0)}{\partial \mathbf{x_{ji}}} = -\phi(\boldsymbol{\beta}'\mathbf{x_i})\boldsymbol{\beta_j},$$

$$(10) \qquad \frac{\partial \Pr(PLIT_i=1)}{\partial \mathbf{x_{ji}}} = (\phi(-\boldsymbol{\beta}'\mathbf{x_i}) - (\mu - \boldsymbol{\beta}'\mathbf{x_i}))\boldsymbol{\beta_j}, \text{ and}$$

$$\frac{\partial \Pr(PLIT_i=1)}{\partial \mathbf{x_{ji}}} = \phi(\mu - \boldsymbol{\beta}'\mathbf{x_i})\boldsymbol{\beta_j},$$

where ϕ is the cumulative density function of the standard normal distribution. The marginal effect for a continuous variable can be calculated at the sample means for the explanatory variables. For a dummy explanatory variable, the marginal effect is found by calculating the probability with the dummy variable held at 1 and then at 0, with all other variables held at their means, then taking the difference between these two probabilities.

Results

Amount of Litter Willing to Sell to an Energy Conversion Facility

Among the 51 farmers who answered all questions pertaining to Equation (1), the average farmer was willing to sell 177 tons of litter per year for energy conversion, or 39% of average tons produced. The estimated Tobit model is significant at the 0.05 probability level (Log-Likelihood Ratio = 32.46; 20 df) (Table 2). The signs of all relationships between the amount of litter a farmer is willing to sell to an energy conversion facility and the significant explanatory variables are as hypothesized with the exception of the cooperative variable and the dump truck variable. The sign on *COOP* is negative, while the hypothesized sign is positive. The hypothesized sign on *DUMP* is positive, but the estimated coefficient is negative. The sign on acres farmed (*ACFARMED*), full ownership (*FULLOWN*), and one of the debt-to-asset variables (*DEBT2070*) are not as expected; however, the estimated coefficients are not significant.

Results suggest that the amount of litter a poultry producer would be willing to sell to an energy conversion facility is positively related to the amount of litter produced on the farm

Table 2. Tobit Model for Amount of Litter Willing to Sell to a Centralized Energy Facility

Explanatory Variable[a]	Coefficient		Standard Error	t-ratio	*p*-value
Intercept	−202.32		178.84	−1.13	0.26
TONSLIT	0.35	***	0.13	2.80	0.01
ACFARMED	0.42		0.35	1.21	0.23
SELLIT	358.51	***	145.11	2.47	0.01
GIVELIT	345.78	***	123.97	2.79	0.01
PASTFERT	−168.03	**	98.18	−1.71	0.09
BROILERS	101.72		126.53	0.80	0.42
SKIDSTEER	537.87	***	145.19	3.70	0.00
SPREADER	−253.91	***	107.54	−2.36	0.02
DUMP	−207.21	**	127.71	−1.62	0.10
FULLOWN	−131.67		104.67	−1.26	0.21
FINC10K	−319.09	***	147.82	−2.16	0.03
FINC1025K	−253.36	**	133.49	−1.90	0.06
FINC2550K	−356.09	***	162.27	−2.19	0.03
PCOFI	−1.18		1.24	−0.96	0.34
DEBT2070	28.64		115.55	0.25	0.80
DEBT70	−171.05		134.00	−1.28	0.20
COLLGRAD	301.97	***	97.82	3.09	0.00
AGEGT65	−92.28		122.56	−0.75	0.45
COOP	−195.91	**	119.36	−1.64	0.10
Sigma	237.53	***	30.54	7.78	0.00
N	51				
Log-Likelihood Ratio (20 df) df)	32.46	***			

[a] Variable definitions are found in Table 1.

Note: *** and ** denote statistical significance at $\alpha = 0.05$ and $\alpha = 0.10$, respectively.

(*TONSLIT*). Dummies representing current disposition of litter are all significant, with the signs on selling litter (*SELLIT*) or giving away litter (*GIVELIT*) being positive and the sign on using litter for pasture fertilization (*PASTFERT*) being negative. Owning a skid steer loader (*SKIDSTEER*) positively affects the amount of litter a farmer is willing to sell, while owning a manure spreader (*SPREADER*) negatively affects the amount of litter a farmer is willing to sell to a conversion facility. The coefficient on broiler production (*BROILERS*) is not significant in the model.

Results further suggest that poultry farmers with higher incomes are willing to sell more litter to an energy conversion facility than those with lower incomes, with the signs on the dummy variables (*FINC10K, FINC1025K,* and *FINC2550K*) being negative. A higher percentage of income from off-farm sources (*PCTOFI*) and debt level (*DEBT2070*, *DEBT70*) have no statistically significant influence. Being a college graduate (*COLLGRAD*) has a positive influence, while being over 65 years old (*AGEGT65*) is not statistically significant.

The marginal effects of the variables on the amount of litter a farmer would be willing to sell for energy conversion are presented in Table 3. Among the dummy variables, the largest positive marginal effects are for having a skid steer loader (*SKIDSTEER*), giving away litter (*GIVELIT*), selling litter (*SELLIT*), and being a college graduate (*COLLGRAD*). The largest negative marginal effects are for having lower incomes (*FINC10K, FINC1025K, FINC2550K*), having a spreader (*SPREADER*), and being a coop member (*COOP*). For each additional ton of litter produced, an additional 0.20 tons is projected to be sold to a conversion facility. If producers give litter away, they are projected be willing to sell 228 more tons than producers who do not give litter away. If producers own skid steer loaders, they are projected to be willing to sell 377 more tons than producers who do not own skid steer loaders.

Willingness to Invest in an Energy Cooperative

A total of 49 farmers answered all questions for the variables included in the Probit analysis of

Table 3. Marginal Effects for the Amount of Litter Willing to Sell to a Centralized Energy Facility

Explanatory Variable[a]	Marginal Effect		Standard Error	t-ratio	*p*-value
TONSLIT	0.20	***	0.07	2.70	0.00
ACFARMED	0.24		0.20	1.20	0.23
SELLIT	207.92	***	80.64	2.58	0.00
GIVELIT	228.07	*	85.35	2.67	0.00
PASTFERT	−103.97	***	65.16	−1.60	0.11
BROILERS	55.76		66.53	0.84	0.40
SKIDSTEER	377.48	***	105.99	3.56	0.00
SPREADER	−126.81	***	46.32	−2.74	0.01
DUMP	−99.26	***	48.97	−2.03	0.04
FULLOWN	−81.25	***	69.14	−1.18	0.24
FINC10K	−132.35	***	44.10	−3.00	0.00
FINC1025K	−112.5	***	43.70	−2.57	0.01
FINC2550K	−131.26	**	35.96	−3.65	0.00
PCOFI	−0.67		0.70	−0.97	0.33
DEBT2070	16.71		69.17	0.24	0.81
DEBT70	−81.77	*	51.45	−1.59	0.11
COLLGRAD	158.26	***	44.36	3.57	0.00
AGEGT65	−49.11	***	61.64	-0.80	0.43
COOP	−110.71	**	65.91	−1.68	0.09

[a] Variable definitions are found in Table 1.

Note: *** and ** denote statistical significance at $\alpha = 0.05$ and $\alpha = 0.10$, respectively.

willingness to invest in an energy cooperative (Equation 5). Of the responding farmers, 55% indicated they would be willing to invest in an energy conversion cooperative. The estimated Probit model is presented in Table 4. The model is significant at the 0.05 probability level (Log-Likelihood Ratio = 48.08; 17 df). It correctly classifies 94% of the observations.

Only the coefficients for giving away litter (*GIVELIT*) and the lowest two income dummies *(FINC10K* and *FINC1025)* are not significantly different from zero. Of the significant variables, *PASTFERT*, *FULLOWN*, and *AGEGT65* have signs contrary to those hypothesized. These results suggest that full owners (sole proprietors) are less likely to invest. A sole proprietor is perhaps more conservative in making investment decisions than others, because the risk of making poor decisions cannot be shared among partners or other owners of an incorporated farm.

The amount of litter produced on the farm (*TONSLIT*) positively influences the probability of investing in an energy cooperative, while the number of acres farmed (*ACFARMED*) negatively affects the probability. Farmers who already sell litter (*SELLIT*) are more likely to invest, while those who produce broilers (*BROILERS*) are less likely to be willing to invest in an energy cooperative than others. Farmers with moderate farm incomes (*FINC2550K*) and greater portions of their household income coming from farming (*PCTOFI*) are less likely to be willing to invest in an energy conversion cooperative. The negative estimated coefficients on the debt-to-asset variables (*DEBT2070*, *DEBT70*) indicate that farmers with high levels of debt are less likely to be willing to invest than farmers with low debt levels. Farmers with a college education (*COLLGRAD*) are more likely to invest than those with less formal education. Those who are already members of a cooperative (*COOP*) and have higher energy costs per square foot of poultry housing (*ECOST*) are more likely to invest in a cooperative that converts litter to energy.

The marginal effects of the variables on willingness to invest in an energy cooperative

Table 4. Probit Model of Willingness to Invest in an Energy Cooperative

Explanatory Variable[a]	Coefficient		Standard Error	t-ratio	*p*-value
Intercept	−5.45	***	2.65	−2.06	0.04
TONSLIT	0.01	***	0.00	2.49	0.01
ACFARMED	−0.02	***	0.01	−2.40	0.02
SELLIT	5.72	***	2.10	2.73	0.01
GIVELIT	2.45		1.80	1.36	0.17
PASTFERT	2.90	**	1.64	1.77	0.08
BROILERS	−9.04	***	3.73	−2.42	0.02
FULLOWN	−3.16	***	1.51	−2.09	0.04
FINC10K	−0.61		1.62	−0.38	0.71
FINC1025K	−0.56		2.34	−0.24	0.81
FINC2550K	−6.84	***	2.99	−2.29	0.02
PCOFI	−0.06	***	0.03	−2.29	0.02
DEBT2070	−2.39	*	1.66	−1.44	0.15
DEBT70	−4.36	*	2.71	−1.61	0.11
COLLGRAD	4.54	***	2.10	2.17	0.03
AGEGT65	6.19	***	2.53	2.44	0.01
COOP	5.32	***	2.44	2.18	0.03
ECOST	3.46	***	1.37	2.53	0.01
N	49				
Log-Likelihood Ratio (17df)	48.08	***			
Percent Correctly Classified	93.88				

[a] Variable definitions are found in Table 1.

Note: ***, **, and * denote statistical significance at $\alpha = 0.05$, $\alpha = 0.10$, and $\alpha = 0.15$, respectively.

are presented in Table 5. Among the dummy variables, the largest positive marginal effects are for being a college graduate (*COLLGRAD*), already selling litter (*SELLIT*), and being a cooperative member (*COOP*). The largest negative marginal effects among the dummy variables are for having broilers (*BROILERS*), having moderate farm income (*FINC2550)*, and having high debt (*DEBT70*). Neither the marginal effects for *TONSLIT* nor *PCTOFI* are statistically significant. For each additional acre farmed (*ACFARMED*), the probability decreases by 0.003. Already selling litter (*SELLIT*) increases the probability by 0.85 compared with not already selling litter.

Pricing of Litter to be Sold

A total of 30 farmers answered all questions for the variables included in the Ordered Probit analysis of litter price category (Equation 8). Of the responding farmers, 27% indicated they would be willing to sell litter at less than $15 per ton, 43% would be willing to sell at $15 to $25 per ton, and 30% would be willing to sell at $25 per ton or more. The estimated Ordered Probit model is presented in Table 6. The model is significant at the 0.05 probability level (Log-Likelihood Ratio = 33.95; 13 df) and correctly classifies 73% of the observations.

The coefficients on the explanatory variables are of expected sign in the estimated model with the exception of *SELLIT*; however, the estimated coefficient is not significantly different from zero for this variable. As expected, the sign on *TONSLIT* is negative and *ACFARMED* is positive. Giving litter away (*GIVELIT*), using it as fertilizer (*PASTFERT*), having broilers (*BROILERS*), and higher percent of off-farm income (*PCTOFI*) all have negative influences on the probability of requiring $25 or more per ton (positive impacts on probability of requiring less than $15 per ton). More indebted farmers (*DEBT2070, DEBT70*), those with moderate farm incomes (*FINC2550K*), and cooperative members (*COOP*) are more likely to indicate they would need a $25 or more (less likely to indicate they need $15 per ton or less).

The marginal effects from the Ordered Probit model are presented in Table 7. The marginal effect for *GIVELIT* is significantly positive for the lowest pricing category. The marginal effect indicates that giving away litter increases the probability of being willing to sell litter at less than $15 per ton by 0.48. Using

Table 5. Marginal Effects of the Variables on Willingness to Invest in an Energy Cooperative

Explanatory Variable[a]	Marginal Effect		Standard Error	t-ratio	*p*-value
TONSLIT	0.00		0.00	1.36	0.17
ACFARMED	−0.00		0.00	1.43	0.15
SELLIT	0.85	*	0.20	4.30	0.00
GIVELIT	0.23		0.24	0.92	0.36
PASTFERT	0.72	***	0.33	2.21	0.03
BROILERS	−0.99	***	0.03	−29.05	0.00
FULLOWN	−0.27		0.20	1.30	0.19
FINC10K	−0.12		0.40	−0.30	0.76
FINC1025K	−0.10		0.50	−0.21	0.84
FINC2550K	−0.99	***	0.02	−52.39	0.00
PCOFI	−0.01		−0.01	1.27	0.20
DEBT2070	−0.66		0.42	1.57	0.12
DEBT70	−0.97	*	−0.10	10.07	0.00
COLLGRAD	0.93	***	0.15	6.16	0.00
AGEGT65	0.59	***	0.20	2.92	0.00
COOP	0.84	***	0.19	4.34	0.00
ECOST	0.52		0.38	1.37	0.17

[a] Variable definitions are found in Table 1.

Note: *** and * denote statistical significance at $\alpha = 0.05$, $\alpha = 0.10$, and $\alpha = 0.15$, respectively.

Table 6. Ordered Probit Model of Price per Ton Required for Litter

Explanatory Variable[a]	Coefficient		Standard Error	t-ratio	*p*-value
Intercept	5.13	***	1.95	2.63	0.01
TONSLIT	−0.00	**	0.00	−1.84	0.07
ACFARMED	0.01	***	0.00	2.54	0.01
SELLIT	−0.65		1.19	−0.55	0.58
GIVELIT	−2.82	***	1.40	−2.02	0.04
PASTFERT	−2.81	***	1.12	−2.51	0.01
BROILERS	−3.29	***	1.66	−1.98	0.05
FINC10K	0.66		1.33	0.50	0.62
FINC1025K	0.15		0.93	0.16	0.87
FINC2550K	1.72	**	1.06	1.62	0.10
PCOFI	−0.04	***	0.01	−3.02	0.00
DEBT2070	2.96	***	1.26	2.35	0.02
DEBT70	3.98	***	2.06	1.93	0.05
COOP	1.46		1.21	1.20	0.23
Mu	2.57	***	0.69	3.74	0.00
N	30				
Log-Likelihood Ratio (13df)	33.95	***			
Percent Correctly Classified	73.33				

[a] Variable definitions are found in Table 1.

Note: *** and ** denote statistical significance at $\alpha = 0.05$ and $\alpha = 0.10$, respectively.

litter as pasture fertilizer (*PASTFERT*) increases the probability the farmer stated they would require $15 to $25 per ton for their litter by 0.56, and decreases the probability the farmer stated they would need $25 per ton or more by 0.80. Having broilers (*BROILERS*) increases the probability the farmer stated they would require $15 to $25 per ton for their litter by 0.66, and decreases the probability the farmer stated they would need $25 per ton or more by 0.89. Farmers with lower incomes tended to be more likely to indicate they would need $25 per ton or more. For *FINC2550K*, the probability of needing $25 per ton or more

Table 7. Marginal Effects of the Variables on Price per Ton Required for Litter

	Marginal Effect at					
Explanatory Variable[a]	PLIT = 0		PLIT = 1		PLIT = 2	
TONSLIT	0.00		0.00		−0.00	
ACFARMED	−0.00		−0.00		0.00	
SELLIT	0.04		0.17		−0.21	
GIVELIT	0.48	***	0.13		−0.61	
PASTFERT	0.24		0.56	**	−0.80	***
BROILERS	0.24		0.66	***	−0.89	***
FINC10K	−0.03		−0.21	***	0.24	
FINC1025K	−0.01		−0.04		0.05	
FINC2550K	−0.06		−0.55	***	0.61	*
PCOFI	0.00		0.01		−0.01	
DEBT2070	−0.09		−0.76	***	0.85	***
DEBT70	−0.13		−0.79	***	0.92	***
COOP	−0.10		−0.37	***	0.47	**

[a] Variable definitions are found in Table 1.

Note: ***, **, and * denote statistical significance at $\alpha = 0.05$, $\alpha = 0.10$, and $\alpha = 0.15$, respectively.

increased by 0.61, while the probability of needing $15 to $25 per ton fell by 0.55. Farmers with higher debt (*DEBT2070, DEBT70*) were also more likely to need $25 per ton or more. Cooperative membership (*COOP*) increased the probability of needing $25 per ton or more by 0.47 and decreased the probability of needing $15 to $25 per ton by 0.37.

Conclusions and Implications

As poultry farmers look toward methods to decrease farm energy costs, to use energy for their operations in a sustainable manner, and to sustainably dispose of litter, their interest should increase in using poultry litter as a potential energy feedstock. However, many poultry farms may not be large enough to produce sufficient litter or have sufficient capital resources to support on-farm litter conversion facilities. An alternative is to convert litter in a centralized facility, which could possibly be structured as a farmer cooperative. A centralized energy conversion facility could be of sufficient scale to economically produce and sell renewable electricity, providing an additional outlet for litter from poultry operations. Finding new outlets for poultry litter in areas of intensive poultry production may be critical as opportunities for land application can be limited by environmental factors such as nutrient loading in the soil and runoff. Furthermore, if this centralized facility is structured as a cooperative, producers could benefit from the sale of the renewable electricity. While several benefits may accrue to producers from a centralized conversion project, in many cases, the litter is already being used as fertilizer or sold. Hence, the value would need to be sufficient to draw the litter from its current uses. This study examined the influences of farm characteristics and farmer demographics on the amount of litter farmers would be willing to sell for energy conversion and their willingness to invest in an energy conversion cooperative. The study also evaluated factors influencing the dollar amount per ton that producers indicated they would need to divert poultry litter from its current uses.

The results from this study suggest that many farmers would be willing to sell a portion of the litter produced on their farms for energy conversion in a centralized energy project. In particular, farmers already selling litter, giving litter away, and who are producing more litter are willing to sell more into such a project. Such a project benefits producers with an alternative market for their farm's litter and could provide the environmental benefit of producing renewable energy. The results also suggest that many farmers would consider investing in a cooperative that would use litter as a feedstock for energy conversion. A cooperatively owned energy conversion facility, in addition to providing an outlet for the poultry operations' litter, could also provide additional income from the sale of electricity onto the grid. Although there are several environmental and business benefits that could accrue to farmers from selling litter for energy conversion, currently, the litter in many cases has some use, either as fertilizer on the producer's farm, a good sold to other farmers, or a good used in trade for poultry house cleanout services. Among those farmers who would sell some of their litter into a centralized or cooperative facility, however, most would sell their litter for $25 per ton or less.

Farmers with operations producing more litter, who are already selling litter or giving it away, have higher farm incomes, and are college graduates are willing to sell more litter into a centralized energy conversion facility and also to invest in an energy cooperative. Farmers giving litter away are not only more likely to sell more litter into a conversion facility, but are more likely to indicate they would need the lowest price ($0 to $15 per ton). Use of litter as fertilizer for pasture, a common on-farm use of litter, negatively influences the amount of litter farmers would be willing to sell, suggesting farmers may view fertilizing pasture as a higher value use than trade for cleanout services. This concept is strengthened with the result that use of litter as pasture fertilizer had a negative influence on farmers needing $25 per ton or more, but it had a positive influence on them needing $15 to $25 per ton. The most indebted farmers were less likely to be willing to change markets to sell into a centralized facility, less likely to be willing to invest in an energy conversion cooperative, and more likely to want $25 or more for their litter. These results suggest that most indebted farmers may be least likely to take on a new market risk and require the greatest premium to switch to a new market for their litter. The negative sign on cooperative membership in the model of tons to be sold to a conversion facility coupled with the positive sign in the cooperative model suggests that farmers who are cooperative members may view selling through a farmer owned cooperative that converts litter to energy as more desirable than selling to a third party owned conversion facility.

This study was conducted analyzing data from poultry producers in a single state. Future research should likely expand the study area to other poultry producing regions. The fact that college education has a positive influence both on willingness to supply a centralized facility and to invest in an energy conversion cooperative hints that producers may factor environmental benefits into their decisions about poultry litter for energy conversion. However, this concept was not investigated directly in this study. Hence, future research might examine the attitudes of farmers toward environmentally sustainable disposal of litter and potential environmental benefits of converting litter to energy.

[Received March 2009; Accepted September 2009.]

References

Armstrong, A., H. Goodwin, and S. Hamm. "Co-processed Poultry Litter and Dewatered Municipal Biosolids: Feasibility as an Alternative Management Approach for Surplus Waste." Paper presented at the Southern Agricultural Economics Association Annual Meetings, Mobile, AL, February 4–7, 2007.

Bachewe, F., W. Lazarus, P. Goodrich, M. Drewitz, and B. Balk. "Review of the Literature on the Economics of Central Anaerobic Digesters." Staff Paper P08-09, University of Minnesota, Department of Applied Economics, October 2008.

Black, W. "Understanding the Cooperative Member." *Farmer Cooperatives for the Future*. L. Schrader and W. Dobson, eds. pp. 143–51. West Lafayette, Indiana: Purdue University, 1985.

Bravo-Ureta, B., and T. Lee. "Socioeconomic and Technical Characteristics of New England Dairy Cooperative Members and Nonmembers." *Journal of Agricultural Cooperation* 3(1988):12–27.

Carreira, R., K. Young, H. Goodwin, and E. Wailes. "How Far Can Poultry Litter Go? A New Technology for Litter Transport." *Journal of Agricultural and Applied Economics* 39,03(2007):611–23.

Carreira, R., H. Goodwin, and S. Hamm. "How Much Is Poultry Litter Worth?" Paper presented at the Southern Agricultural Economics Association Annual Meetings, Orlando, FL, February 4–8, 2006.

Cunningham, D. "Broiler Production Systems in Georgia 2007–2008 Costs and Returns Analysis" The University of Georgia. Department of Poultry Science. Internet site: http://pubs.caes.uga.edu/caespubs/pubs/PDF/B1240-3.pdf (Accessed September 8, 2008).

Department of Energy (DOE). Bioenergy. Internet site: http://www.energy.gov/energysources/bioenergy.htm (Accessed August 11, 2009).

Environmental Protection Agency (EPA). "Funding On-Farm Biogas Recovery Systems: A Guide to Federal and State Resources." EPA Report 430-F-04-002. K. Roos, H. Zygmunt, and S. von Feck, eds. Internet site: http://www.epa.gov/agstar/pdf/ag_fund_doc.pdf (Accessed March 18, 2009).

Flora, J. and C. Riahi-Nezhad. "Availability of Poultry Manure as a Potential Bio-Fuel Feedstock for Energy Production." University of South Carolina, Report to the South Carolina Energy Office, August 2006.

Goan, C., L. Warren, B. Park, and R. Roberts. "Production and Utilization of Poultry Litter in Tennessee." Paper presented at the Poultry Science Association 91st Annual Meeting, Newark, DE, August 11–14, 2002.

Greene, W. *Econometric Analysis*. 6th ed. Upper Saddle River, New Jersey: Prentice Hall, 2008.

Howry, S., A. Stoecker, D. Storm, and M. White. "Economic Analysis of Management Practices to Reduce Phosphorus Load to Lake Eucha and Spavinaw." Paper presented at the Southern Agricultural Economics Association Annual Meetings, Dallas, TX, February 2–6, 2008.

Kemper, N., H. Goodwin, and M. Mozaffari. "The Nitrogen Fertilizer Value of Baled Broiler Litter for Cotton Production in the Arkansas Delta."

Paper presented at the Southern Agricultural Economics Association Annual Meetings, Dallas, TX, February 2–6, 2008.

Kubsch, K. "Cooperative Anaerobic Digestion as a Manure Management Alternative in Northeastern Wisconsin." Research Study Summary. University of Wisconsin, Green Bay. September 5, 2003.

LaCapra Associates. "Analysis of a Renewable Portfolio Standard for the State of North Carolina." 2006. Internet site: http://www.lacapra.com/downloads/NC_RPS_Report.pdf (Accessed April 13, 2009).

Lewis, J. "Bio-Gas Plants and Hog Farming in North Carolina." Duke University, North Carolina, Spring 2001. Internet site: http://www.econ.duke.edu/dje/2001/lewis.pdf (Accessed March 18, 2009).

Myers, M.E., and C. Deisinger. "Developing a Community Manure Digester Model for Wisconsin." Report by Cooperative Development Services, USDA. June 2006.

Puaha, H. "Investment Decisions in New Generation Cooperatives: A Case Study of Value Added Products (VAP) Cooperative in Alva, Oklahoma." Paper presented at the Southern Agricultural Economics Association Annual Meetings, Mobile, AL, February 1–5, 2003.

Stofferahn, C. "Individualism or Cooperation: Preferences for Sharing Machinery and Labor." *Journal of Cooperatives* 18(2004):1–17.

Wachenheim, C., R. deHillerin, and M. Dumler. "Producer Perceptions of Hog Marketing Cooperatives." *Journal of Cooperatives* 16(2001): 25–45.

Whittington, A. "Availability of Poultry Litter as an Alternative Energy Feedstock: The Case for Mississippi." Paper presented at Southern Agricultural Economics Association Annual Meetings, Mobile, AL, February 4–7, 2007.