What does the introduction of energy crops mean for the crop mix and cellulosic ethanol plant location in Louisiana?

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Introduction

In recent years the Mississippi Delta has underwent some significant crop land allocation changes that have been spurred by both the US energy and farm policies. Significant energy policies that have influenced the expansion of the ethanol industry are: the banning of Methyl Tertiary Butyl Ether (MTBE), 2005 Energy Policy Act, and the 2007 Energy Independence and Security Act. A new Renewable Fuels Standard (RFS) was passed in 2007 with the ratification of the Energy Independence and Security Act, mandating that fuel producers use at least 36 billion gallons of biofuels by 2022 and placed an emphasis on the production of cellulosic ethanol (OPS, 2007). The Food, Conservation, and Energy Act of 2008 is also beginning to play a role with the implementation of the Biomass Crop Assistance Program (BCAP) that helps to defray some of the establishment costs of these crops.

With the implementation of these new policies several states, especially in the Mississippi Delta are beginning to see significant changes in crop acreage allocations. For example, in Arkansas, Louisiana, and Mississippi the planted acres of cotton from 2006 to 2007 dropped by 26, 47, and 46 percent respectively (NASS, 2009). The decrease in cotton acres for these states were replaced almost 1 for 1 with corn acres. A potential reason for this major switch is that on average the US corn prices were $2 and $1.16 higher per bushel than in 2005 and 2006, respectively. Significant changes in cropland allocations are beginning to change the face of the Mississippi Delta agricultural landscape as producers respond to market signals to increase the production crops used in biofuel production (Figure 1).

In the near future with the introduction of second generation biofuels that could potentially be additional cropland allocation changes that take place. This is going to be highly dependent upon the crops available for production in a given region. For example, in Louisiana some of the crops that are being considered for use in second generation biofuels are switchgrass, hybrid poplar, energy cane, sweet sorghum, and miscanthus. Given that Louisiana has a fixed amount of land available for crop production the introduction of any of these crops could further change the agricultural landscape of the state. Furthermore, many of the potential energy crops used in the production of second generation biofuels are not traditionally grown in the state. The only exception to this is energy cane which is just high fiber sugarcane (ASCL, 2007).

Specifically, this study focuses on the Louisiana Sugarcane Belt as farmers in this region are looking for additional crops to add into their portfolio due to stagnate sugar prices and rising input prices. The Sugarcane Belt of Louisiana is small self contained area comprised of about 21 parishes in Southern Louisiana (Figure 2). This makes the Sugarcane Belt a unique area to study because the only crops produced in the area are sugarcane, rice, and soybeans; whereas, in the Midwest there would be many more crops to take into consideration. Furthermore, this study considers the introduction of energy cane and switchgrass, non-traditional crops, into the portfolio of potential crops that can be grown. Conservation reserve program acres could also be impacted depending upon whether this land is available for producers to grow a crop like switchgrass on. The first objective is to examine the potential changes in the crop mixes a county level for two different cases. An optimization land allocation model is constructed to maximize the net returns for each county. The second objective of this paper is to determine optimal cellulosic ethanol plant location(s) based on the new optimal land allocations for each county. This is accomplished by minimizing the transportation costs of biomass produced in the state.

Methodology

In order to determine the optimal crop mix within the region net returns are maximized for each county. The optimal crop mix model takes into consideration the total usable and tillable acres including all farmland that is currently in production plus conservation reserve program (CRP) acres. However, for the purposes of this study CRP acres can only have switchgrass grown on them.

Optimal Crop Mix

The objective function of the optimal crop mix model is shown in Equation 1.1. The net returns (*NR*) per acre for each crop (*i*) are multiplied by acres (*AC*) in each parish (*j*). Equations 1.2, 1.3a, and 1.3b are the three primary constraints for this model. Equation 1.2 limits the total acres of all crops to be less than or equal to the total amount of usable or tillable acres in each parish. Total usable and tillable acres include all farmland that is currently in production. CRP acres are included as a separate constraint because they are only eligible for switchgrass production. Equations 1.3a and 1.3b set forth the minimum and maximum acreage for each crop for each parish. For example, the average rice acres in Jeff Davis Parish over the past five years have been 12,000 acres; therefore, the minimum and maximum would be set at (+/-) fifteen percent of the current level. By doing this the sensitivity of acreage allocations can be observed as the minimum and maximum levels are changed. Equations 1.4 and 1.5 are additional equations that allow specific situations to be analyzed. For example, assume the Verenium cellulosic ethanol plant located in Jennings, Louisiana decides it wants to produce 25 million gallons of cellulosic ethanol. Equation 1.4 can be implemented to ensure that the required tons of biomass are produced.

A mathematical representation of the optimal crop mix is as follows:

$$\max Z = \sum_{j=1}^{n} NR_i AC_j \qquad (1.1)$$

s.t. .

$$\sum_{i=1}^{m} l_i \leq usable_j \tag{1.2}$$

$$a_{ij} \geq \min_{ij} \tag{1.3a}$$

$$a_{ij} \leq \max_{ij} \tag{1.3b}$$

$$\sum_{j=1}^{n} bio_j \geq min_{bio} \tag{1.4}$$

$$X_j, l_i, a_{ij}, bio_j \geq 0 \tag{1.5}$$

<u>*Plant Location*</u>

Optimal location of cellulosic ethanol processors is the last aspect of this framework that is investigated. Given that the introduction of these new crops could influence the optimal crop mix for the state a cost minimization model is developed to determine the least cost locations for potential cellulosic ethanol plants to be constructed. Now using the optimal crop mix for each county, the optimal location for a cellulosic ethanol processing facility based on transportation costs can be determined.

Using geographic information system software is used to map all of the potential routes that could be used in the transportation of biomass from the centroid of one county to the next. It should be noted that the accuracy of this calculation would increase if the distance between every field and each possible ethanol plant location could be determined; however, this information is not available. Using this information a distance matrix is created and the optimal location for the lowest transportation costs can be determined. These potential locations are ranked according to the cost of transportation of the required biomass to the facility, and the location that has the least cost in transportation will be the optimal location.

The transportation model that is used is:

$$\min Z = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij} x_{ij} \quad (2.1)$$

s.t. .

$$\sum_{j=1}^{n} x_{ij} = s_i \quad (2.2)$$

$$\sum_{i=1}^{m} x_{ij} = d_j \quad (2.3)$$

$$x_{ij} \geq 0 \quad (2.4)$$

Data

Data for yields, production acreages, land in farms, and number of farms is collected from "Quick Stats" (NASS, 2009). The base case land allocation scenario per county is shown in Conservation Reserve Program acres are collected from NRCS (2009). Net returns above variable costs plus government payments for each of the individual crops can be determined based upon the Louisiana State University production budgets (Salassi and Deliberto, 2009(a); Salassi and Deliberto, 2009(b)). The two exceptions to this are energy cane and switchgrass. Mark et al. (2009) provide the net returns for these crops.

Results

Optimal Crop Mix

The introduction of energy cane and switchgrass into the production portfolio is alters the optimal land allocation of the region. The optimal crop mix model maximizes returns above variable cost for the region at $195,079,547. This does also include government payments for rice and soybeans. Table 1 under new optimal crop mix is the new land allocations by county for the region. In general, every county picks up additional acres for each crop but in of particual interest come in at their maximum allowable amount for all counties except for one (Iberia). Energy canes entrance is a function of the pricing method for energy cane. Under the current method of determining the price energy cane producers are paid 90 percent of their production cost plus a variable amount of $6.00 per ton for the realized yield (Mark, 2009). Furthermore, the largest majority of energy cane acres entering the model lie on the periphery of the Sugarcane Belt. Specifically, significant amounts of land enter the model on the Northwest periphery of the belt in St. Landry, Point Coupee, and Jefferson Davis counties. This is significant because for the majority of sugarcane harvested in this region is have to be transported almost 100 miles for processing. Many of the mills are actually considering letting these producers go because of the transportation costs. Another group of counties that has a significant amount of energy cane acres entering is in the Southeast corner of the belt. Overall, there is 152,318 acres energy cane that comes into production. A conservative average of 35 tons per acre, 5.4 million tons of biomass is produced to be processed into cellulosic ethanol.

In addition to energy cane acres there are an additional 24,652 acres of switchgrass that come into production on CRP land. Switchgrass in Louisiana is expected to yield about three tons per acre making it unlikely to be adopted on a wide scale in Louisiana specifically in this region when there are crop that have much greater yield potential (i.e. sweet sorghum and mischanthus).

Optimal Processing Plant Location

Using the optimal crop mix the optimal plant location dependent upon transportation cost is located. Table 2 contains the rankings for the counties and the cost to transport all of the biomass produced to one centralized location. Realizing that there are 5.4 million tons that has the potential to make over 400 million gallons of cellulosic ethanol it is not likely that this big of a plant would be located in one place. The more likely solutions it that there would be multiple plants located around the state in order to further minimize transportation costs. The most likely locations will be on the periphery of the region were the majority of energy cane is being produced. However, currently the model is not capable of doing this because it requires additional distance information.

Conclusions

The addition of energy cane and switchgrass into portfolio of crops available for production resulted in 5.4 million tons of biomass being produced for conversion to cellulosic ethanol. These 5.4 million tons of biomass has the potential to produce 400 million gallons of cellulosic ethanol. The largest portions of energy cane production come into production in the periphery counties of the belt. Furthermore, these counties account for the largest portions of the current sugar industries transportation costs because the majority of the still operating sugar mills are located in the heart of the belt. Based on this it is estimated to take $26 million a year to transport all of this biomass from where it is produced to one central location for processing. It would not be expected that this would be how the industry would develop because a 400 million gallon plant is several times larger than any conventional ethanol plant operating. Overall, the addition of new crops into the available portfolio of crops is going to have an impact on the crop mix in the region and thus impact transportation costs which are significant driver in the profitability of a cellulosic ethanol plant.

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Figure 1: Historical Distribution of Primary Crop Acreages for Mississippi Delta

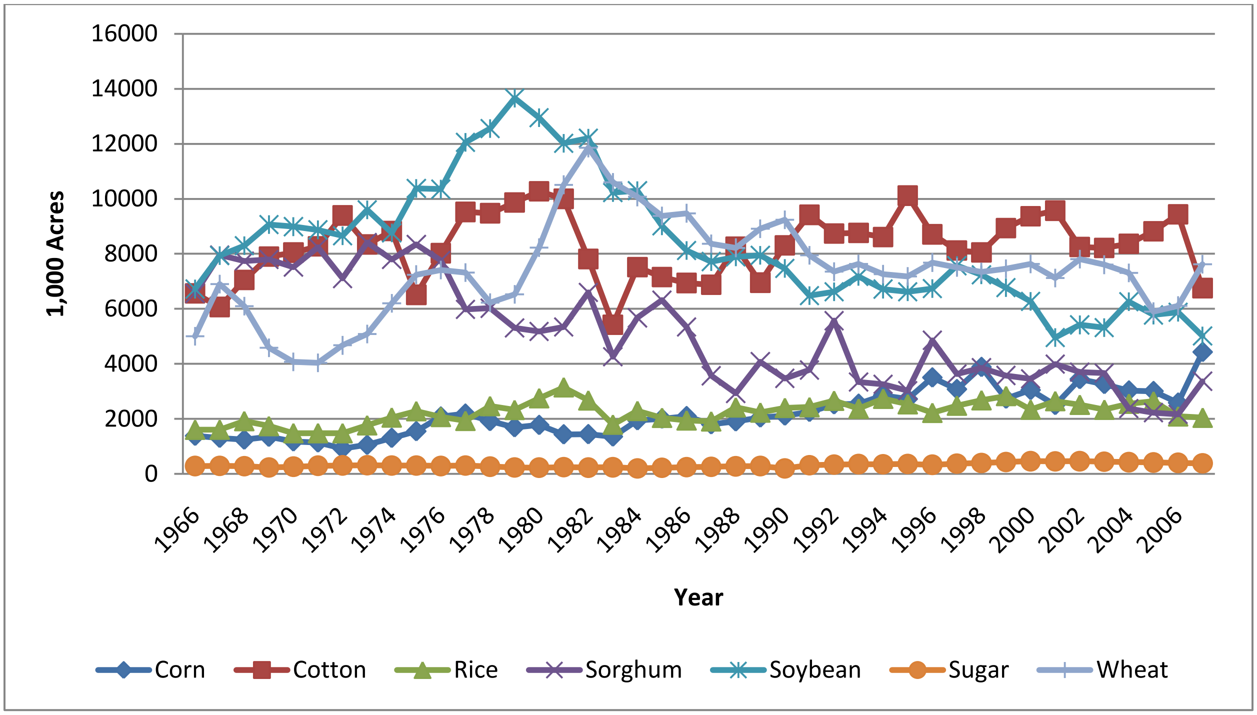

Figure 2: The Louisiana Sugarcane Belt and Sugar Mill Locations

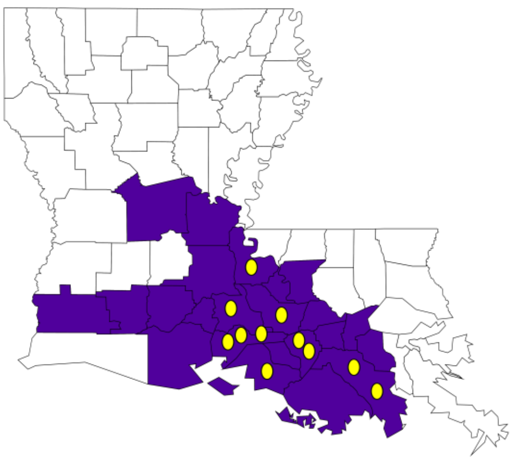

Table 1: Cropland Allocations

			Base Case (ac)				New Optimal Crop Mix (ac)					
County	Farms	Land in Farms	Rice	Soybean	Sugarcane	Switch on CRP	Rice	Soybean	Sugarcane	Energy Cane	Switchgrass	Switch on CRP
Acadia	905	232,934	77,020	37,420	2,478	0	88,573	43,033	2,850	17,538	0	0
Ascension	277	45,455	0	950	17,180	0	0	1,093	19,757	2,720	0	0
Assumption	114	63,694	0	0	30,740	0	0	0	35,351	4,611	0	0
Avoyelles	947	278,465	14,380	67,160	14,320	12,329	16,537	77,234	16,468	14,379	0	12,329
Calcasieu	971	376,822	11,420	2,520	2,736	0	13,133	2,898	3,146	2,501	0	0
Evangeline	806	172,224	42,360	19,740	784	4,617	48,714	22,701	901	9,433	0	4,617
Iberia	345	115,893	0	4,660	52,780	0	67,069	3,961	44,863	0	0	0
Iberville	175	85,729	0	9,060	32,140	0	0	10,419	36,961	6,180	0	0
Jefferson Davis	706	288,100	74,800	16,040	3,967	1,078	86,020	18,446	4,562	14,221	0	1,078
Lafayette	713	67,422	5,250	4,850	12,660	0	6,038	5,578	14,559	3,414	0	0
Lafourche	440	106,119	0	0	25,360	0	0	73,151	29,164	3,804	0	0
Pointe Coupee	441	190,550	2,300	61,540	30,080	0	2,645	70,771	34,592	14,088	0	0
Rapides	977	177,300	8,300	24,500	11,380	3,737	9,545	28,175	13,087	6,627	0	3,737
St. Charles	58	8,651	0	0	1,729	0	0	0	1,988	259	0	0
St. James	64	43,251	0	0	26,400	0	0	0	30,360	3,960	0	0
St. John	31	13,699	0	0	6,290	0	0	0	7,233	944	0	0
St. Landry	1,401	298,369	23,260	73,400	11,974	2,892	26,749	84,410	13,769	16,295	0	2,892
St. Martin	355	78,878	5,133	6,420	29,940	0	5,903	7,383	34,431	6,224	0	0
St. Mary	142	72,728	575	3,000	40,340	0	489	3,450	46,391	6,587	0	0
Terrebonne	169	178,472	0	0	8,900	0	0	0	10,235	1,335	0	0
Vermilion	1,182	290,318	61,200	5,700	28,520	0	70,380	6,555	32,798	14,313	0	0
West Baton Rouge	128	25,820	0	5,275	13,960	0	0	6,066	16,054	2,885	0	0

Table 2: Rankings of County Transportation Costs

Rank	County	Transportation Costs
1	St. Landry	$26,646,425
2	Acadia	$27,664,031
3	Lafayette	$27,700,077
4	Evangeline	$31,033,204
5	West Baton Rouge	$32,509,399
6	Pointe Coupee	$33,597,395
7	Avoyelles	$34,397,774
8	Vermilion	$34,430,548
9	Jefferson Davis	$34,747,472
10	St. Martin	$36,733,285
11	Iberia	$37,427,716
12	Iberville	$38,402,706
13	Rapides	$38,874,714
14	Ascension	$40,757,298
15	St. Mary	$44,294,774
16	St. James	$45,709,645
17	Calcasieu	$45,986,562
18	Assumption	$46,920,165
19	St. John	$48,263,855
20	St. Charles	$53,054,220
21	Terrebonne	$56,398,759
22	Lafourche	$61,575,574