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Determining the Optimal Location for Collocating a Louisiana Sugar Mill and a New Cellulosic Ethanol Plant

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Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meetings, Birmingham, AL, February 4-7, 2012

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Introduction

Supplying the current and future market for renewable energy in the United States will require a large basket of energy sources from many different technologies. In the liquid fuels sector, ethanol has a large role to play and will have an increasingly important role in the next decade. While the vast majority of this country's ethanol is currently produced from corn, this is by no means the only option. With the rise of cellulosic ethanol, many alternatives open up, including the production of fuel from sugarcane waste fiber. Additionally, ethanol can be obtained from sugar-bearing crops like sugarcane and sugar beets.

In February of 2010, the EPA finally concluded its years-long review of the original RFS and released its new standard, the RFS2. The long-term goals of producing domestic ethanol didn't change, and the short-term production targets were only changed modestly. However, there is one major change that is relevant to this study. Under the RFS, there is a category of biofuel called "advanced biofuel," a designation that includes ethanol from sugarcane juice. Since the RFS standards call for 21 billion gallons of advanced biofuels by 2022, and 16 billion gallons of that from cellulosic ethanol, that leaves a 5 billion gallon mandate for other advanced biofuels that could be filled by ethanol from sugarcane juice, which would include juice from "energy cane" as it is just a high-fiber variety of sugarcane.

Louisiana

One of the advantages of building an ethanol system around Louisiana sugarcane is that much of the infrastructure is already in place. The area has long had sugarcane fields and mills in desirable spatial relationships. From a logistical standpoint, overlapping a sugarcane ethanol

system on top of the existing sugar infrastructure could provide additional synergies. If existing sugar mills could also process cane into ethanol and if sugarcane farmers grew some mix of both traditional sugarcane and energy cane, they would be able to send all of their harvest to the same place, and the output would be a mix of ethanol and sugar.

Objectives

Previous studies have examined optimal plant locations for a standalone cellulosic ethanol plant located in the Louisiana sugar belt. Such a plant would effectively have to compete with existing bioprocessing facilities (sugar mills) for natural resources, land, and transportation and infrastructure resources during sugarcane season, but could benefit from the same factors during the offseason.

Other work has previously shown that collocating a cellulosic ethanol plant with a sugar mill generates significant synergistic benefits in the form of shared capital, feedstock management, and transportation costs. However, this work simply examined a generic representative sugar mill in the Louisiana sugar belt.

Combining these two lines of research, a more specific and accurate picture of the potential Louisiana cellulosic ethanol industry can be obtained. This research specifically examines the relative viability of collocating a cellulosic ethanol plant with some of Louisiana's eleven sugar mills. Using a GIS-based transportation model, each mill is examined for feedstock availability and transportation costs. Capital sharing advantages are the same for each of the sugar mills, so the feedstock availability and transportation costs are where the mills can potentially be differentiated, in addition to the calculated value of the actual collocated plant.

Methods

There are two basic characteristics of each sugar mill that should indicate their baseline viability: grinding capacity and latitude. All else being equal, the economies of scale captured in a cane-based ethanol plant are highly dependent on the ability of the plant to process large quantities of biomass material at a high rate. Because the collocated facility would use the grinders and rollers from the previously-existing sugar mill, larger mills with higher daily grinding capacity will be preferred over mills with a lower throughput. Similarly, the farther north the mill is, the larger the number of acres there are that could theoretically be used for the production of energy cane. Energy cane is more cold hardy than traditional sugar varieties, and with increasingly cool average temperatures, the gap between revenue potential for an acre of energy cane and an acre of sugar cane narrows, even with high sugar prices. With unseasonably cold weather, less value potential is lost from an acre of energy cane than from an acre of sugar cane, as the fibrous portion of the crop is relatively unaffected by freezes.

The three mills chosen for examination are Cora Texas, Alma, and Enterprise. They each have seasonal grinding capacities in excess of one million tons, as required by the collocation model. Alma and Cora are the two farthest north, and Enterprise is the largest plant overall, though a bit farther south than the other two. The capacities of each mill are summarized in Table 1.

The calculation of transportation costs is undertaken by reversing a GIS model used to calculate optimal plant locations. In that model, optimal location of cellulosic ethanol processors was investigated via a GIS model. Using the crop mix for each parish, the optimal location for a cellulosic ethanol processing facility based on static transportation costs was determined. Geographic Information System (GIS) software was used to map all of the potential routes that

could be used in the transportation of biomass from the centroid of one parish where cane acres were located, to the centroid of the parish where the prospective plant was located.

For this study, the model was instead given fixed locations for the ethanol plants and the equations were solved for the transportation costs. 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. GIS provides a distance matrix and the transportation costs are based on the number of acres in the region. The transportation radius around each ethanol plant is allowed to expand until enough acreage has been captured to fill the capacity of the plant. For example, the Enterprise sugar mill is located in Iberia Parish. There is sufficient cane acreage within that one parish to fill the sugar mill and a collocated ethanol plant without having to transport any across parish lines, so its transportation costs are relatively low.

The cellulosic ethanol plant is modeled using previous research into standalone and collocated ethanol plants, and parameters are based primarily on the most recent NREL specifications for lignocellulosic ethanol production. The collocated ethanol plant is simulated using these parameters as well as those of the Louisiana sugar mills chosen for study, and the model is built as a 25 year time-horizon net present value simulation model. The NPV of each prospective collocated ethanol plant is simulated over 500 iterations in the Excel add-on, Simetar. Most of the parameters are simulated using a multivariate empirical distribution (MVE) with a few using GRKS, triangle, and empirical distributions, as the data limitations required. For details on the distributions or any of the supporting equations for the models, please ask the authors or see the previous studies.

Results

In order to evaluate the desirability for collocation of the three mills considered for this study, the potential production of sugar and cellulosic ethanol were taken into consideration and a net present value has been estimated. Prior to the NPV being estimated a transportation model was employed to provide an initial indicator to which mill would be preferred just based on transportation costs and mill size. This model revealed that Enterprise would be the preferred location and Alma would be the second most desirable location. However, a downside to this model is that it is not dynamic, unlike the dynamic NPV model employed. Again, the two key drivers of the NPV for each of the mills is the cost of transportation and the mill's grinding capacity. Table 3 shows the results of this model.

The results indicate that Alma, the northernmost of the mills, is a desirable location for the collocation of a cellulosic ethanol plant. Under the current assumptions the simulation model generates an estimated mean NPV of \$207.87 million. However, it was only the second most desirable mill for collocation, primarily because it has a smaller daily grinding capacity and larger transportation radius from which it must source biomass, relative to Enterprise. Enterprise had an NPV of \$231.35, almost \$24 million or 11% more than Alma. A key driver of this is its proximity to a large number of sugar cane acres relative to the other mill locations. Figure 1 shows the historical sugarcane acres for the home parishes for the three different mills. New Iberia is home to Enterprise sugar mill and on a yearly basis it has almost 20,000 more acres of sugarcane relative to the parishes in which the other mills are located. This is a downside to using Enterprise as the plant chosen for collocation. Enterprise is located in the heart of the sugar

belt for Louisiana and it is unlikely that growers in the area would consider the production of energy cane nearby, given current sugar prices.

One surprising result revealed by the model is that Cora is the least desirable of the three and has a higher variability in its NPV than the other two. Cora has the second highest grinding capacity and it was expected it would be the second best location. However, lower sugarcane acreages available in Iberville Parish and surrounding parishes have driven the transportation costs for Cora higher than the other two mills. Another key thing to notice in Figure 1 is that sugarcane acreage around the Cora mill has plateaued, whereas acreages around the Alma mill are still on the rise. This is a result of the higher than average sugar prices and many of the sugarcane acres that have been out of production since the early 2000's are starting to be put back into production.

Figure 2 shows the historical sugarcane acres for Louisiana from 2000-2010. When the sugarcane industry went through its contractions many of the first acres to go were on the northern edge of the sugarcane belt. It is expected that with the development of the cellulosic ethanol industry in Louisiana, if sugarcane or energy cane is used then there is room for significant growth in acreage in this Northern portion of the Belt. Even more acres could be available for energy cane though because it tends to be more cold tolerant than the traditional sugarcane varieties. However, this will be highly depending on other commodity prices because the further North you move in Louisiana the more enterprises the cellulosic ethanol industry will have to compete with.

Conclusions and Discussion

From these results, an interesting if deceptive picture emerges. Because one of the utilized models is dynamic in nature and the other is static, some of the information about the crop and

acre availability is necessarily limited in usefulness. Rather than being interpreted as an actual measure of acres available or potential success of the collocation project at the individual mill, these results should be considered more of an indicator of ideal potential outcomes. In future work, the two models will be brought into better coordination, and the measurements will gain better descriptive power.

In actuality, the mill most likely to serve as a good collocation choice is Alma, the northernmost mill. The value of the project at Enterprise is considerably higher, but this value assumes that the collocated plant would be able to obtain the acres necessary to fill the plant's capacity. It is true that the overall picture looks healthiest for Enterprise: it has the highest potential acreage, the lowest transportation costs, and the highest average temperatures of the three mills studied. However, these conditions also make it ideal for sugar production, and thus the truth of the situation is that every acre that can be put to producing sugar generally should be.

At Alma, the situation is considerably different in one important respect. As can be seen in Figure 3, Alma is rather farther north than Enterprise, about 47 miles farther, per Google data. More importantly, the temperatures in the area are significantly different. The yearly average temperature around Alma is 66.9 degrees, versus 68.1 for Enterprise. During the harvest window of October through December, those numbers are 59.5 and 61.3, respectively, almost a two degree (3%) difference. For a crop that is as sensitive to cold as traditional sugar cane is, this difference can be significant, as is the fact that the first killing frost would generally be correspondingly earlier.

What then can we conclude from all of this? The raw results seem to indicate that Enterprise is the best choice for collocation, while the reality of the mill situations seem to indicate that Alma would be the better choice. In truth, there is actually very little discrepancy

between these conclusions. What the results actually indicate, given all their limitations, is that all three of these mills would be an acceptable choice to collocate an ethanol plant, though transportation costs would be minimized if the mill were located in a prime sugarcane-planting location. However, these lower transportation costs would not have any actual impact if the energy crops could not be reasonably planted in the region. Alma does have higher transportation costs, but its relative unattractiveness for sugarcane means that the more cold-tolerant energy cane varieties would have a greater relative advantage, and thus a higher attractiveness for growers. If the transportation costs were so much larger that the collocated plant were unprofitable, then Alma would not be a viable choice, but that is clearly not the situation here.

This study is quite limited by the inability of the two models to dynamically communicate, but the results are at least indicative of the fact that this area of study justifies further investigation. If the transportation and crop mix model were altered such that it not only changed and communicated directly with the NPV model, but also responded to the same dynamic changes of the simulated market parameters, a much more complete picture could be obtained. This could include a better measure of which mills would actually have the best chance of success, as well as measurements indicating the relative feasibility of each project.

Table 1 – Grinding Capacities of the Sugar Mills Studied

	daily capacity (tons)	annual capacity (based on 90 day season)
Alma	14,400	1,298,000
Cora Texas	16,200	1,456,000
Enterprise	20,300	1,826,000

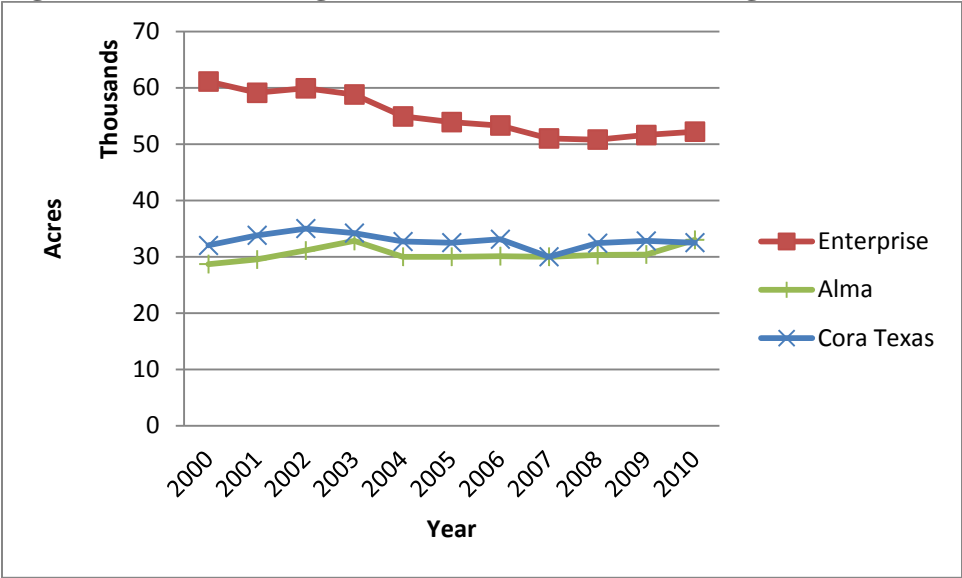
Table 2: Mill Cane Sources and Average Miles Cane Travels

	Enterprise	Alma	Cora Texas
Parishes Cane Procured from	Iberia	St. Charles, Calcasieu, Acadia, Evangeline, Pointe Coupee	St. Charles, St. John, Calcasieu, Acadia, Iberville, Evangeline
Average Miles Traveled	0	84.4	78.8

Table 3: Results for Collocation Desirability

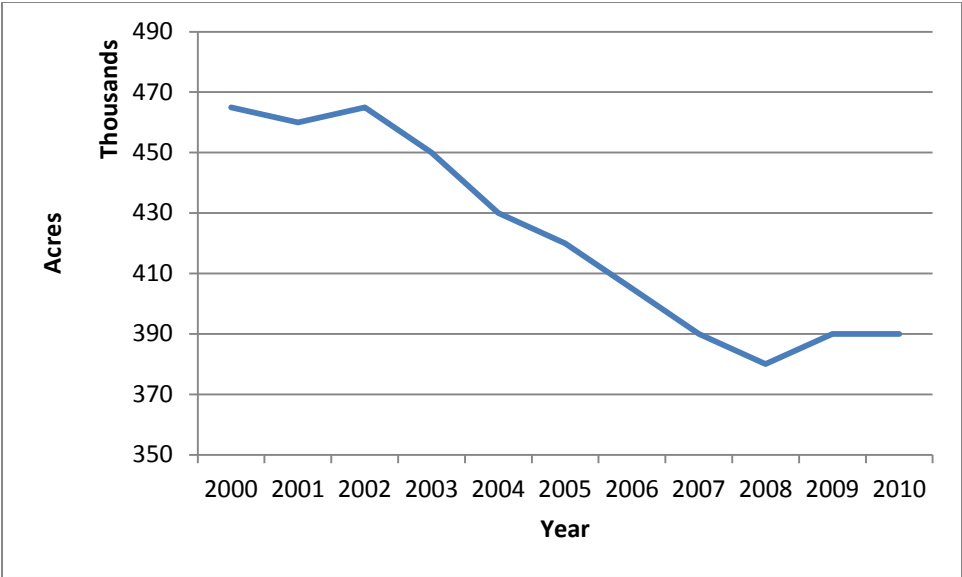
	Alma (base)	Enterprise	Cora Texas
Mean NPV	\$ 207,870,000	\$ 231,350,000	\$ 197,010,000
difference		11%	5%
StDev	12,311,000	12,413,000	12,270,000
CV	5.92	5.37	6.23
Min	\$ 170,110,000	\$ 193,670,000	\$ 159,240,000
Max	\$ 248,120,000	\$ 272,090,000	\$ 237,060,000

Figure 1: Historical Sugarcane Acres for Louisiana Sugar Mills



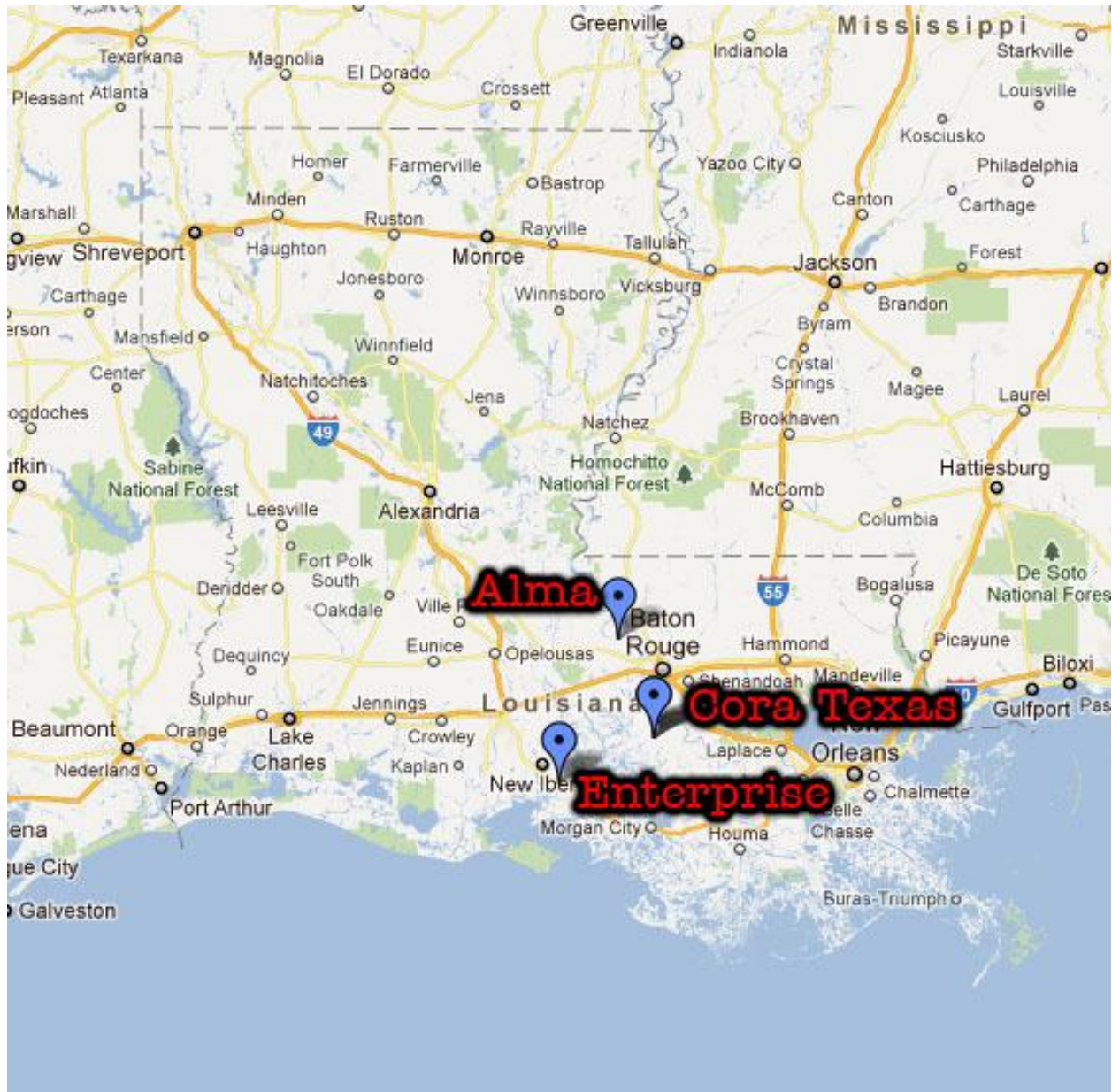
Source: USDA, 2012

Figure 2: Historical Louisiana Sugarcane Acres



Source: USDA, 2012

Figure 3 – Locations of the Sugar Mills Studied



Source: Google Maps, 2012