BIOFUELS PRODUCTION IN THE UNITED STATES

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BIOFUELS PRODUCTION IN THE UNITED STATES

Biofuels in the U.S. have gained the attention of the agricultural industries. Interest in biofuels has gained impetus from several forces. The main drivers have been government mandated such as the MTBE ban in many states, mandates for the inclusion of ethanol in gasoline, blending subsidies, and low sulfur requirements for diesel. In addition, the high price of energy and a desire to become more energy independent have led to the interest in renewable energy. However, the rapid increase in biofuel production has led to increased prices for feed and food grains leading some to question whether there will be enough grain available for human consumption globally. While people of high income nations are not at risk, there is a concern for people in low income nations.

To understand the potential size of U.S. biofuel demand, currently the U.S. consumes 140 billion gallons of gasoline and 50 billions gallons of diesel per year. Biofuel consumption represents roughly 3.4 percent of gasoline consumption and 0.4 percent of diesel consumption. Given the infrastructure in the U.S., a natural cap on the consumption of ethanol is 10 percent or roughly 14 billion gallons. This cap is due to the current automobile technology. Unless the vehicle is a flex-fuel vehicle, the manufacturer's warrantee does not extend far beyond a 10 percent ethanol blend.

This article will look at the biofuels industry in the United States. Specifically, it will examine ethanol production in the U.S. and provide a comparison of the cost of production with ethanol produced from sugarcane, currently the major competitor. Next the article will examine some of the issues associated with corn production in the U.S. and the concerns regarding possible production. A brief section on biodiesel and butanol production will be presented followed by a discussion of future issues concerning biofuel production.

Global Ethanol Issues

Global ethanol production totaled about 13.5 billion gallons in 2006. The United States (4.855 billion gallons) surpassed Brazil (4.491 billion gallons) in 2006 to become the global leader (Table 1). Together the two countries produce about 69 percent of the world's ethanol with China producing roughly another 7.5 percent.[1]

One of the key issues is the feedstock used in ethanol production. Of the top ten ethanol producing nations, Brazil and India rely heavily on sugarcane (Table 1). The United States, China, Germany, and Canada mostly rely on feed or food grains for ethanol production[2]. South Africa relies on both sugarcane and corn. France and Russia use grain and sugarbeets as feedstocks for ethanol production.

To have a framework for understanding how ethanol production is affecting the global marketplace for food and feed grains, it is important to understand the potential of various feedstocks. According to Randy Schlatter of Pioneer, one acre of corn that produces 160 bushel per acre will yield 439 gallons of ethanol[3]. An acre of sugar beets which that yields 23 tons would produce 552 gallons of ethanol. An acre of Brazilian sugarcane that yields 31.5 tons per acre produces 727 gallons of ethanol. Thus from a pure conversion of ethanol per land area, sugarcane has a comparative advantage.

In addition to the gross productivity, it is important to consider the cost of producing a gallon of ethanol. While estimates of production costs for ethanol production in Brazil and the U.S. differ from study to study, it is generally agreed upon that Brazil holds a competitive advantage over the U.S. According to a study by Martines-Filho, Burnquist, Vian, the variable

[1] Renewable Fuels Association - http://www.ethanolrfa.org/industry/statistics/#E
[2] Earth Policy Institute - http://www.earth-policy.org/Updates/2005/Update49_data.htm
[3] Schlatter, Randy, "Linking the Seed To the Energy Need" presented at MAB in the Heartland Conference, Junction City, Kansas, April 19, 2007.

cost of producing ethanol is roughly $0.96 per gallon in the U.S. and $0.89 per gallon in Brazil[4]. In terms of fixed costs, the cost per gallon in the U.S. ranges from $1.05 to $3.00 per gallon while it is about $0.21 per gallon in Brazil. Part of the reduced fixed cost in Brazil is due to a production system that allows sugarcane to be processed either into sugar or ethanol. The additional cost of adding ethanol production to an existing sugar processing plant is low.

U.S. Ethanol Industry

Ethanol production in the United States has increased rapidly in the last few years. In 2000, there were 54 plants in operation in the United States with annual capacity of 1,748.7 million gallons. On August 1st 2007, there were 124 operating ethanol plants with an annual total capacity of 6,484.4 million gallons. Seven of these existing plants were undergoing expansion and 76 new plants were under construction. When the new plants and added capacity comes online by the end of 2008, ethanol production capacity in the United States will be approximately 12.98 billion gallons per year.[5]

On average, one new ethanol plant becomes operational in the United States each week. The typical new plant is 100 million gallons in size. Each new plant adds about 39 million bushels to corn demand. In total, the ethanol demand for corn has increased from about one billion bushels, or 11 percent of U.S. total corn production, in the 2002/03 crop year to an estimated 3.4 billion bushels, or about 27 percent of total production in 2007/08 (Figure 1). To reach the capacity of 12.98 billion gallons capacity in 2008, 5.06 billion bushels of corn will be required. [6]

[4] Martines-Filho, Joao , Heloisa L. Burnquist, and Carlos E. F. Vian, "Bioenergy and the Rise of Sugarcane-Based Ethanol in Brazil," *Choices*, 21,(2nd Quarter 2006) - http://www.choicesmagazine.org/2006-2/tilling/2006-2-10.htm
[5] Renewable Fuels Association – http://www.ethanolrfa.org/locations/
[6] World Agricultural Supply and Demand Estimates, USDA, WASDE-449, August 10, 2007 and KSU estimates.

Corn has become the principle crop in the United States, planted on more acres than any other single crop. The main drivers for the increased production have been growing demand for corn from livestock producers; domestic and overseas, growing human consumption of corn products, and industrial use of which ethanol has been growing fastest. Corn acreage increased by 19 percent from 2006 to 2007in response to higher corn price. With an expected trend yield of 154.1 bushel per acre, a record corn crop of over 13 billion bushels is expected in 2007 (Figure 2). Assuming the 5.06 billion bushels required and no further acreage increases in corn production, ethanol production will consume about 39 percent of the U.S. corn crop. To satisfy ethanol demand, corn acreage will need to expand again in 2008 by approximately 6% to 98.3 million acres (Table 3). This will put upward pressure on all commodities that compete with corn for available land.[7]

Although corn is a relatively expensive crop to grow, productivity, measured by yield, has been increasing at a greater rate for corn than for any other major field crop (Figure 3). Randy Schlatter indicates that Pioneer expects that productivity gains will increase in the future to meet the increased demand for feed grain. Because of the relative inelasticity of demand for corn, seed corn breeders have more incentive to focus on yield characteristics when the crop becomes relatively scarce as opposed to other traits when the commodity is in abundance. Schlatter indicates that the current commercial record for corn production is 442 bushel per acre.

In addition to breeding corn for increased yield, it is also likely that corn will be also bred to be more efficient in the production of ethanol. Currently the endosperm is used for ethanol production with each bushel of corn yielding 2.5 gallons of ethanol. Modifying the seed to produce more starch will lead to increased ethanol production with some estimating that each bushel of corn may yield 2.9 gallons of ethanol within 10 years. As the technology for

[7] World Agricultural Supply and Demand Estimates, USDA, WASDE-449, August 10, 2007 and KSU estimates.

converting cellulose to ethanol becomes economically feasible on a commercial scale, it is estimated that the pericarp and stover could yield an additional 118 gallons per acre within the next five years.[8]

Even with growing use of corn by ethanol producers, the United States remains the leading corn exporting country in the world, supplying an estimated 63 percent of global exports in 2007/08 (Figure 4). This is down from the historical average of about two-thirds.[9]

Ethanol producers receive no direct subsidies from the U.S. government. Small plants are eligible for feasibility study grants and government guaranteed loans. The main government support for ethanol production is paid to motor fuel blenders, which buy ethanol to produce gasoline/ethanol blends. They receive a $0.51 per gallon tax credit for each gallon of ethanol purchased.

The United States imported about twelve percent of total ethanol use in 2006. Brazil was the largest direct supplier (Table 2) and likely was the source of the rest of the imports by transshipping through Central American and Caribbean countries to avoid the $0.54 tariff per gallon import duty. There have been proposals to reduce or eliminate the $0.54 per gallon U.S. import duty on ethanol. There is evidence to suggest that Brazilian producers can ship lower cost sugar-based ethanol to U.S. coastal markets, pay the import duty, and still compete successfully with Midwest produced starch-based ethanol. The high cost of trucking Midwest ethanol to the East or West Coast gives imported Brazilian ethanol a competitive advantage.[10]

The major co-product of ethanol production is distiller's grain. From one bushel of corn, approximately 17 pounds of distiller's grain (out of 56 pounds) which retains the corn's protein,

[8] It should be noted that equally impressive technology is close to being commercialized in the production of sugarcane, and the conversion of sugarcane into ethanol.
[9] World Agricultural Supply and Demand Estimates, USDA, WASDE-449, August 10, 2007, page 23.

[10] Renewable Fuels Association - http://www.ethanolrfa.org/industry/statistics/#F

fiber, vitamins, and minerals. Distiller's grains, the relative price of which is determined by the price of corn, are replacing corn in livestock rations, primarily ruminants. In 2007-08, ethanol plants in the U.S. will produce about 25.9 million metric tons of distiller's grains. Nearly all of these distiller's grains will be used in the domestic market although there has been growth in container shipments of dry distiller's grains to overseas buyers. Mexico imported 438,000 metric tons of dry distiller's grains in the last year[11]. Thailand, Indonesia, the Philippines, Malaysia, and Vietnam are also importers of distillers grains. It is estimated by the U.S. Grains Council that a potential export market of 20 million metric tons exists for distiller's grains[12].

Many plants use natural gas to evaporate the moisture from distiller's grains to produce dry distiller's grains with solubles, DDGS. However, an emerging trend is to build ethanol plants close to cattle feeding facilities and feed distiller's grains wet, (wet distiller's grains, WDGs) eliminating the cost of natural gas to dry them. Transportation cost and rapid spoilage limits the distance that WDGs can be shipped to about 100 kilometers.

Cellulosic Ethanol

The Bush administration announced in early 2007 a proposed mandate of 35 billion gallons of ethanol use by 2017. It is generally believed that the practical limit for starch-based (corn) ethanol production in the U.S. is about 15 billion gallons per year. The difference, 20 million gallons, is expected to be from cellulosic ethanol. Cellulosic ethanol is produced by converting the lignocellulose in plant materials to ethanol.

In February 2007, the U.S. Department of Energy awarded six grants totaling $385 million to stimulate commercial development of cellulosic ethanol plants. The plants will be located in different parts of the U.S. and use a variety of feedstock including grass, corn stover,

[11] U.S. Grains Council - http://www.grains.org/galleries/default-file/06-21-07%20-%20Mexico.pdf
[12] U.S. Grains Council - http://www.grains.org/galleries/headlines/01-18-07%20-%20Keefe%20Release.pdf

wheat straw, and forestry waste. Although the process of converting cellulosic biomass into ethanol has been proven in a laboratory, commercial scale production is not yet economically viable. Currently, the capital cost per gallon of capacity to build a cellulosic ethanol plant is 2.5 to 4 times greater than the capital cost per gallon of a starch-based plant. Plant sizes are small, about 10 million gallons per year, compared to the 100 million gallon capacity of new ethanol plants raising issues regarding economies of scale in transportation. In addition, poor conversion efficiency results in a much higher per gallon cost to produce cellulosic ethanol compared to starch ethanol. Ethanol from cellulose may become a major source of fuel in the future, but it will play a minor role for the next few years.

BioDiesel

Biodiesel production has increased dramatically worldwide, with the European Union the global leader. Biodiesel production the United States has expanded from two million gallons in 2000 to about 250 million gallons in 2006. There were 148 U.S. plants in operation in early 2007 with annual production capacity of 1.39 billion gallons. When all plants presently under construction come online, U.S. biodiesel production capacity will be approximately 3.28 billion gallons. The rapid growth has been stimulated by government incentives and high petroleum diesel prices.[13]

Currently, the industry has significant idle capacity. This is due to a run up in soybean oil price, the primary, but not only, feedstock for biodiesel production in the United States. About 80 percent of a biodiesel plant's operating cost is feedstock expense. At the current petroleum diesel price, soybean oil must be $0.30 per pound or less in order for a biodiesel plant to break even. Recently, soybean oil price has been $0.35 per pound or higher. In addition, engine manufacturers have been slow to approve the use of biodiesel in engines for warranty purposes,

[13] National Biodiesel Board – http://www.biodiesel.org/pdf_files/fuelfactsheets/Production_capacity.pdf

although more approvals are being granted. There is an indication that government support will continue and perhaps increase. In addition, in some of the more marginal production areas, canola offers a potential opportunity as a feedstock. But at this point, expansion of production and use of biodiesel in the United States hinges on feedstock price.

Butanol

Biobutanol is an alternative to ethanol that is less developed but offers potential advantages. Butanol is a four carbon alcohol that is currently used as an industry solvent. Bio-technology advances have made it possible to produce butanol from biomass materials through fermentation. The advantages to butanol are that the properties are similar to gasoline so that it can be mixed from zero percent to 100 percent with no engine modification. In addition, one of the issues with ethanol is that it absorbs water. Therefore ethanol is not able to be transported in the current U.S. gasoline pipeline system, making it expensive to transport from production regions to consumption regions. Butanol is not susceptible to water absorption and therefore could be distributed much more cheaply. In addition, ethanol has reduced fuel mileage (70 percent) compared to gasoline. Butanol obtains similar results to gasoline.

Historically, a bushel of corn produced 1.3 gallons of butanol. Recent advances now produce 2.5 gallons of butanol from a bushel of corn, roughly the equivalent of ethanol.[14] While the technology is on the horizon, the economic feasibility is still not commercially viable, though research continues on biobutanol.

Conclusions

The biofuel industry in the United States is rapidly developing. However, the success of the industry is not guaranteed. Currently, the ethanol industry is succeeding because of government mandates, subsidization, import tariffs, current corn prices, and high oil prices. At

[14] http://www.butanol.com/page5.html

oil prices in the $70 per barrel range, ethanol production is economically feasible even without subsidization and import tariffs. However, if oil prices would drop, the U.S. ethanol industry would retrench.

In addition, the market for distiller's grains is an important factor that will affect the success of the ethanol producers. The domestic market is quickly becoming saturated and unless alternative markets are developed, the viability of the industry may be affected. Another important factor is the competition for land. The demand for corn for the ethanol industry is currently reaching a level where it will become difficult to attract additional acres from other crops. Thus, the potential exists for a run-up in corn and other commodity prices that could negatively affect ethanol industry profitability.

Similarly, the bio-diesel industry is not economically viable due to high vegetable oil prices. Excess capacity exists for the production of bio-diesel and unless the U.S. government would choose to mandate the use of bio-diesel, it is likely that the industry will struggle unless vegetable oil prices decline.

The verdict on the biofuel industry in the U.S. is still in doubt. Much infrastructure has been developed that will remain in place even if the economic picture declines. The build-up for the U.S. farm producer will result in fewer U.S. farm program payments, higher land rents, and ultimately higher land values. Whether these outcomes are sustainable will be determined over the next decade.

Table 1. Leading Ethanol Producing Countries and Feedstock Used

Country	**Primary Feedstocks**	**2006 Production** (Mil.Gallons)
United States	Corn	4,855
Brazil	Sugarcane	4,491
China	Corn, Wheat	1,017
India	Sugarcane	502
France	Sugarbeet, Wheat, Corn	251
Germany	Rye, Wheat	202
Russia	Wheat, Sugarbeet	171
Canada	Corn, Wheat, Barley	153
Spain	Wheat, Barley	122
South Africa	Corn, Sugarcane	102

Source: Renewable Fuels Association and Earth Policy Institute

Table 2. U.S. Imports of Fuel Ethanol by Country, 2006

Country	**Quantity** (Millions of Gallons)
Brazil	433.7
Jamaica	66.8
El Salvador	38.5
Costa Rica	35.9
Trinadad & Tobago	24.8
Total	653.3

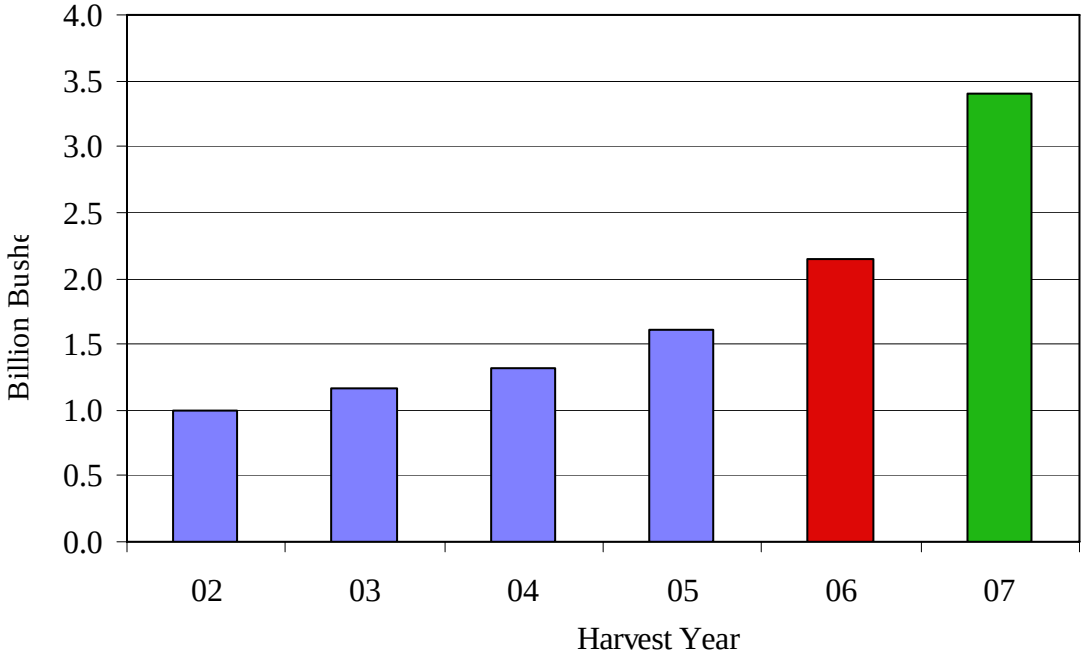
Source: Renewable Fuels Association, 8/2/2007.

Table 3. U.S. Land in Crops (Millions of acres)

Crop	5 year Average	2007/08 USDA estimate
Corn	79.6	92.9
Soybean	74.2	64.1
Hay	62.4	61.8
Wheat	59.5	60.5
Cotton	14.1	11.1
Grain Sorghum	8.1	7.8
Principle Crops	322.0	320.1
Conservation Reserve	35.9	35.9
Total Land in the U.S.	441.6	441.6

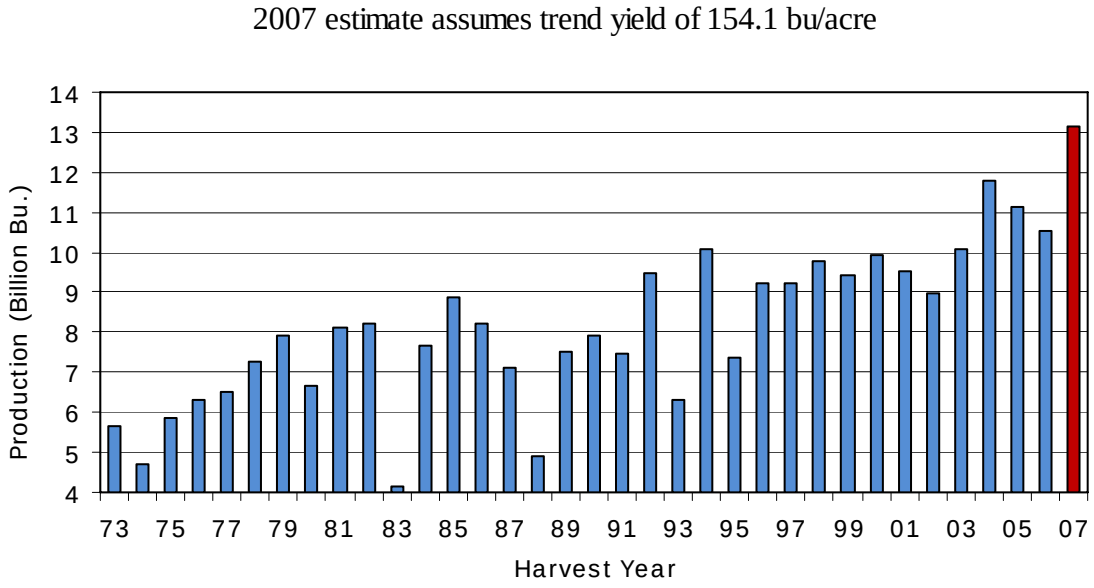
Source: World Agricultural Supply and Demand Estimates, USDA, July 12, 2007 and reports for the previous five years.

Figure 1. Corn Used for Ethanol Production, U.S., 2002 to 2007



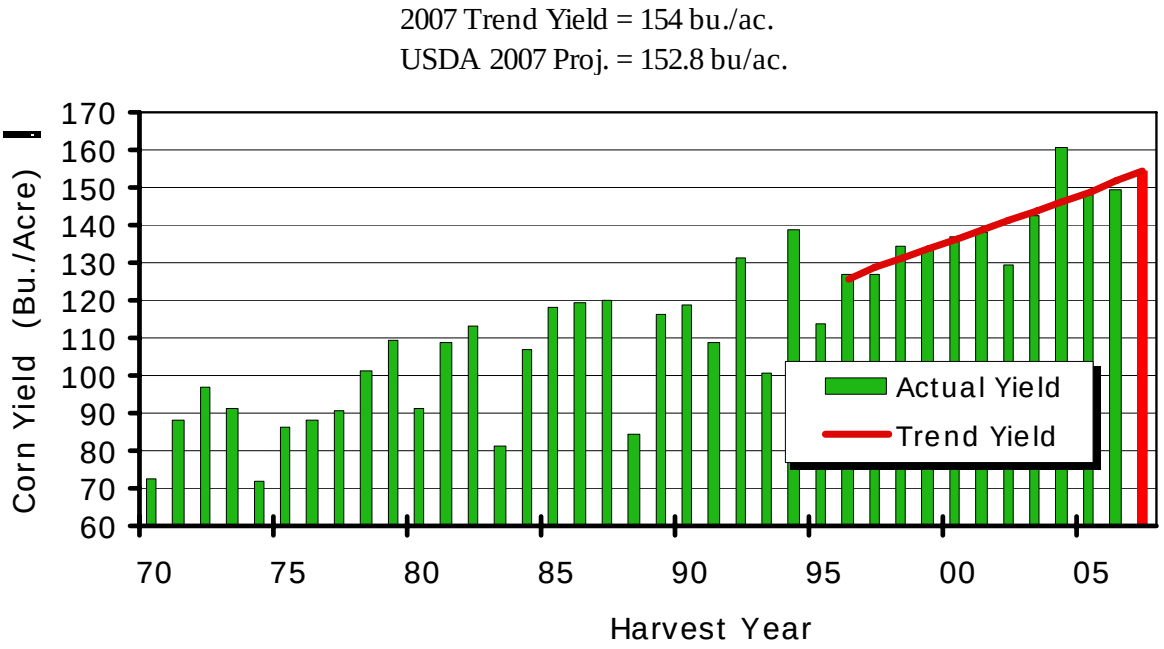
Source: USDA and WASDE 8.10.07

Figure 2. History of United States Corn Production



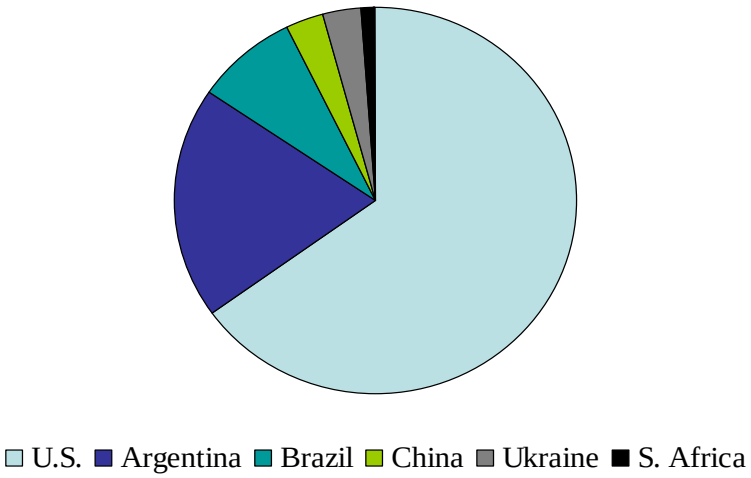
Source: USDA and WASDE 8.10.07

Figure 3. Corn Production Productivity, U.S., 1970 to 2007.



Source: USDA and WASDE 8.10.07

Figure 4. United States Share of Global Corn Exports, 2007/08



Source: World Agricultural Supply and Demand Estimates, USDA, August 10, 2007.