Feedstock Supplies for U. S. Biodiesel Production

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Summary

President George W. Bush signed into law the Energy Independence and Security Act of 2007 (EISA) on December 19, 2007. The legislation was designed to reduce U.S. dependence on foreign oil by increasing the supply of alternative fuels. EISA requires increased biofuel production from various sources, including biodiesel. In addition to the federal renewable fuels standard, some U.S. states – most notably, California – have adopted, or are in the process of adopting, policies that could expand utilization of biodiesel as a result of its greenhouse gas reduction benefits. The purpose of this paper is to analyze the availability of domestic feedstock that could be used to meet these potential new demands without affecting existing uses (e.g. the animal feed industry).

The biodiesel industry has experienced significant growth in production over the past five years. In 2007, approximately 500 million gallons of biodiesel were produced in the United States. It is estimated that nearly 700 million gallons of biodiesel were produced in 2008. During this time period, biodiesel producers have made use of a variety of fats and oils sources, including soybean oil, inedible tallow and greases, yellow grease, canola oil, imported palm oil, and corn oil generated from ethanol facilities.

Although many opportunities exist for new feedstocks for biodiesel production, it is relatively clear where near term supplies will be generated. Approximately ¾ of a billion gallons of soybean oil should be available for biodiesel production in 2012, and higher oil content oilseeds such as camelina and canola can add more than 200 million gallons of feedstock supplies. Although lacking a supply response, animal fats and yellow grease can have a significant impact on biodiesel production; potentially adding more than 400 million gallons of production by 2012. Including 400 million gallons of feedstock from U.S. ethanol plants, more than 1.8 billion gallons of feedstock from domestic sources would be available for biodiesel production by 2012.

More difficult to quantify are opportunities such as decreased exports, expanded U.S. processing capacity, and greater use of brown grease that may add even greater amounts of feedstock by 2012. These sources will be highly dependent upon commodity economics, market forces, and global policy. Should conditions prove favorable, more than 4.3 billion gallons of feedstock from domestic sources may be available for biodiesel production. Other new feedstock sources could prove to be equally important to future biodiesel growth. The current feedstock supply situation has sent numerous price signals to the market to invest in new technologies and methods to increase raw material supplies. Investment in new, non-edible raw materials sources such as algae, jatropha, mustard, pennycress, and halophytes continues at an aggressive rate.

In addition to questions related to feedstock supplies, policy requiring specific quantities of biodiesel also brings industry plant capacity to the forefront. There are presently 176 companies, with an annual plant capacity of 2.6 billion gallons, which have invested millions of dollars into the development of biodiesel manufacturing plants.

In summary, neither equity investment in plant capacity nor feedstock supplies represent a constraint in the marketplace for production of sufficient quantities of biodiesel to meet the RFS2 requirements for one billion gallons of biomass derived diesel by 2012 or state policies requiring similar amounts of fuel such as the California low carbon fuel standard.

Background
Government policies are being enacted to utilize higher volumes of alternative fuels, such as biodiesel, for a number of stated benefits including energy independence, economic security, and an improved human health and natural environment.

President George W. Bush signed into law the Energy Independence and Security Act of 2007 (EISA) on December 19, 2007. The legislation was designed to reduce U.S. dependence on foreign oil by increasing the supply of alternative fuels. EISA requires increased biofuel production, 36 billion by 2022, and must be met, in part, from biodiesel.

EISA differentiates between "conventional biofuel" (corn-based ethanol) and "advanced biofuel." Advanced biofuel is renewable fuel, other than corn-based ethanol, with lifecycle greenhouse gas emissions that are at least 50 percent less than greenhouse gas emissions produced by gasoline or diesel. EISA also requires the use of one billion gallons of biomass based diesel fuel by 2012.

In addition to the federal renewable fuels standard, states are beginning to enact comprehensive greenhouse gas reduction policies that rely on low carbon fuels such as biodiesel for compliance. The most prominent such policy is California's low carbon fuel standard which some estimate could account for more than one billion gallons of biodiesel utilization by 2020.

Near Term Soybean Supplies
The biodiesel industry has experienced significant growth in production over the past five years. In 2007, approximately 500 million gallons of biodiesel were produced in the United States. It is estimated that nearly 700 million gallons of biodiesel were produced in 2008.[1]

During this time period, biodiesel producers have made use of a variety of fats and oils sources, including soybean oil, inedible tallow and greases, yellow grease, canola oil, imported palm oil, and corn oil generated from ethanol facilities. The U.S. Census Bureau documents production, consumption, and stocks of fats and oils through the "M311K - Fats and Oils: Production, Consumption, and Stocks" survey. In 2007, soybean oil was the feedstock used to generate approximately 80 percent of production (roughly 400 million gallons), while in 2008 soybean oil represents roughly 60 percent of production through November.

Two relevant statistics can be derived from this census information. First, the use of soybean oil for biodiesel production represented only 14 percent of domestic soybean oil consumption in 2007. Although overall biodiesel production grew in 2008, the amount of soybean oil used for the production of biodiesel will remain similar to 2007 figures. Second, the use of animal fats, yellow grease, and other non-edible vegetable oils are largely responsible for the increase of biodiesel production in 2008.

The November 10, 2008 World Agricultural Supply and Demand Estimates released by USDA projected the 2008 soybean crop would be 2.92 billion bushels based upon harvested acreage

[1] Production statistics derived from U.S. Census statistics collected on M311K survey.

of 74.4 million acres and an average national yield of 39.3 bushels/acre. U.S. soybean processors are projected to process 1.745 billion bushels of soybeans with another 1.02 billion bushels exported.

USDA projected 3.1 billion pounds of soybean oil (an estimated 413 million gallons of potential biodiesel) to be utilized in the production of biodiesel. In addition, soybean oil exports were projected to be 2.3 billion pounds (an estimated 307 million gallons of biodiesel).

<u>Soybean Virtual Acres—new technology will add significantly to the U.S. raw material supply</u>—
As indicated previously, soybean oil has been the most utilized feedstock to date in the U.S. Based upon historical yield trends, domestic production of soybeans will continue to increase. However, a major research focus of companies such as Pioneer and Monsanto has been to create “virtual acres” through stepwise enhancements in yield technology and/or oil content. Monsanto plans to introduce new technology that can increase soybean yields 9 to 11 percent. Pioneer, a DuPont Company, is commercializing soybean varieties that increase yields by as much as 12 percent. After years of research investments by the life science companies, these technologies have reached commercialization and are set to have a meaningful impact on soybean yields in 2010. More than 90 percent of U.S. farmers currently utilize herbicide-resistant soybean varieties, demonstrating farmers’ willingness and desire to adopt technology that can enable improved profits through increased yields or decreased costs. If this same 90 percent of U.S. soybean acres adopted the new yield technology, more than 60 million acres could see a 10 percent increase in yield. This equates to more than 250 million additional bushels of soybeans (the equivalent of 380 million gallons of biodiesel) without increasing acreage in the U.S. Although technology will enable increased production per acre, realization of additional vegetable oil supplies will be dependent upon an expansion of oilseed processing capacity. Stated a different way, protein demand will need to increase to create an economic incentive to expand processing capacity to process additional bushels.

The same benefit can be achieved by increasing soybean oil content. Current industry genetic programs suggest 10 percent oil increases are achievable within the next few years, and increasing soybean oil content by that percentage would generate approximately 120 million gallons of additional oil if adopted on 50 percent of soybean acreage. New approaches for achieving even higher oil levels in plants are being actively researched. Previous efforts focused on increasing the flow of carbon into the oil biosynthesis pathway. However, downstream bottlenecks appear to reduce the value of this approach. The National Biodiesel Board (NBB) has partnered with The Donald Danforth Plant Science Center to identify novel approaches to enhance oil production in soybeans and other oilseeds. This work centers on the hypothesis that the ability to utilize available carbon limits oil production. Therefore, the Danforth Center’s work will focus on engineering carbon sinks that will pull metabolites through the oil production process in plants. This is a three-year program that was initiated in 2008.

The soybean industry will continue to play a key role in providing feedstock for the biodiesel industry for years to come. Based upon current technology available to soybean producers, if processing capacity expands it is reasonable to project the production of at least 780 million gallons of biodiesel with existing soybean oil supplies in 2012. This estimate does not take into consideration soybean oil exports, amounting to more than 300 million gallons of soybean oil in 2008, which could be diverted into domestic biodiesel production. Nor does it take into account an estimated one billion bushels of soybeans that are exported and could be a source of biodiesel feedstock if the domestic crushing industry further expanded capacity.

Near Term Yellow Grease Supplies
As reported in, *Statewide Feasibility Study for a Potential New York State Biodiesel Industry, May 5 2004*, recycled cooking and restaurant greases are collected and processed primarily by the independent rendering sector since it is generally not a practice for packer or processing facilities to process yellow grease. Although the supply and availability of waste grease is difficult to quantify, approximately 300 million gallons of biodiesel could be produced from yellow grease generated in the United States[2].

It is estimated that a very high percentage of used cooking/restaurant grease is capable of being collected from restaurant and food operations. According to the U.S. Census, 1,484,711,376 pounds of yellow grease (estimated 185.6 million gallons) were generated in 2007. Accordingly, 62 percent of the potential recycled cooking oils in the U.S. were collected and processed into yellow grease.

Realistically, all waste oils are not collected and other uses for yellow grease exist. The primary markets have been the use of yellow grease as a feed ingredient for livestock, poultry, companion animals, and aquaculture. Recent policy changes that allow yellow grease-based biodiesel to receive the $1 biodiesel blenders tax credit are expected to encourage substantially more collection of used cooking oils and restaurant grease and also shift the economics of yellow grease toward biodiesel production versus other markets.

In 2007, 47 percent of the inedible grease produced (which includes yellow grease) in the U.S. was exported.[3] If 50 percent of potential yellow grease supplies were converted to biodiesel, approximately 150 million gallons of biodiesel could be produced from that feedstock. The National Renderers Association estimates yellow grease supplies will grow by 4 percent between 2008 and 2012,[4] thus an additional 156 million gallons of biodiesel could be produced in 2012.

Near Term Animal Fats Supplies
Animal fats are derived from the rendering process using animal tissues as the raw material. The raw material is a byproduct of the processing of meat animals and poultry. The amount of fat produced is directly related to the species of animal processed and the degree of further processing that is associated with the marketing/distribution of the meat product. Derived from U.S. Census Bureau statistics, approximately 964 million gallons of biodiesel could have been produced from animal fats generated by the rendering industry in 2007.

Similar to yellow grease, current markets of rendered fats include use as feed ingredients for livestock, poultry, companion animals and aquaculture. In addition, products such as edible tallow are used for soap and fatty acid production. Industry analysts anticipate that roughly 25 percent of the rendered animal fat supplies could be diverted to biodiesel production given current uses. Thus, approximately 240 million gallons of biodiesel could be produced nationally

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[2] Based upon the assumption that 9.4 lbs of recycled oils are generated per capita, 85% conversion rate to yellow grease, and a U.S. population of 300 million.
[3] U.S. Census Bureau, Oils, Production, Consumption, and Stocks – 2007, Issued June, 2008
[4] Personal communication with National Renderers Association, November 2008.

from rendered animal fats. The National Rendering Association forecasts rendered fat supplies to grow approximately 6 percent by 2012,[5] thus an estimated 254 million gallons of biodiesel could be produced from rendered fats in 2012.

Fat Production (metric tons) in 2007 U.S. Census Bureau		
Source		Estimated Biodiesel
	mmt	*gallons*
Inedible Tallow	1,272,500	350,573,750
Edible Tallow	811,400	223,540,700
Lard	211,200	58,185,600
Poultry Fat	624,800	172,132,400
Other Grease	579,000	159,514,500
		963,946,950

Increased Raw Material Availability—Crops and Technology Contributing to Expansion of Raw Material Supplies

Raw material supplies for biodiesel production will also include:

- Other oilseeds with high-oil content (camelina, canola, etc.);
- Expansion of vegetable oil supplies from ethanol production;
- Expanded domestic oilseed crushing capacity.

Camelina

Just as biodiesel producers are fond of saying that biodiesel can be used in any application that diesel fuel is used, camelina is said to be adapted to any region where wheat can be grown. Researchers and producers indicate the crop can be grown in arid conditions, prefers lower humidity levels, does not require significant levels of inputs such as fertilizer, and the oil will produce a high quality biodiesel. Typical varieties of camelina contain approximately 38 to 40 percent oil. Camelina performs well under drought stress and can yield up to 2,200 pounds per acre (1,200 to 1,500 lbs/acre can be typical) in areas with less than 16 inches of annual rain. Camelina is thought to be ideal for cool regions where canola production is challenging.

At least two firms are offering contracts in 2009 to producers with stated goals of achieving two million acres of production in the near future. The extent to which camelina acreage increases in the near term will be dependent upon numerous factors including:

- Success of breeding programs to increase yield and oil content;
- Expansion of crush locations;
- Addition of risk management options for growers (e.g. crop insurance);

[5] Personal communication with National Renderers Association, November 2008.

- The extent to which camelina is competitive with other crops (e.g. wheat).

The six-year average of wheat acreage between 2002 and 2007 in Colorado, Idaho, Montana, Nebraska, North Dakota, Oregon, Washington, and Wyoming was 21.86 million acres. If 2 million acres of camelina were grown (less than 10 percent of the wheat acreage) and processed utilizing mechanical extraction, approximately 116 million gallons of oil could be added to the market.[6]

Canola

Canola is a type of rapeseed that was first developed in the 1970s. Canadian plant breeders developed canola explicitly for its health advantages compared to industrial rapeseed. Original rapeseed's nutritional content has always been questioned due to its high levels of elcosenoic and erucic fatty acids, the latter having been shown to be linked to heart disease. In the 1960s, Canada began researching rapeseeds by isolating specific lines that were low in erucic acid to

produce an oilseed that could be considered safe for human consumption. The result of these efforts was "Canola," defined as oil that contains less than 2 percent erucic acid.

Canola is a popular crop throughout the world because of its variety of uses and its health value compared to competing oilseeds. Canola can be produced in some countries where similar crops are not able to grow because of short growing seasons. In the U.S., North Dakota is the leading producer of canola. Both spring and winter (fall planted) canola have been found to be a good rotation crop with wheat in several states, helping break up plant diseases that occur in fields where wheat is grown every year. Canola oil has been increasing its market share in the

[6] Assumes 35% oil content and average yields of 1,500 lbs/acre.

United States because of its nutritional advantages compared to other competitive vegetable oils. Although canola oil would primarily move into edible markets, increased U.S. acreage will have positive impacts on the overall vegetable oil supply.

The U.S. Canola Association has established goals and programs to expand canola acreage to two million acres by 2010.[7] Canola in the U.S. is almost exclusively grown as a spring crop. However, a significant portion of the goal would be achieved by expanding winter canola acres in the Pacific Northwest, Great Plains, and mid-South. Similar to camelina, the extent to which winter canola is successful will be dependent upon the economic returns offered to farmers versus other rotation crops (e.g. wheat). Vegetable oil from increased canola acreage would most likely be utilized in edible products rather than biodiesel due to the premium value of canola oil. However, expanding canola acreage still benefits the biodiesel industry by creating a larger supply of vegetable oils, allowing more soybean (and palm) oil to be used for biodiesel without affecting edible oil supplies. The projected increase in U.S. canola acreage by 2010 has the potential to add more than 100 million gallons of oil to the overall vegetable oil supply.

Corn Oil

The changing biofuels landscape creates the opportunity to benefit from increased ethanol usage. Ethanol producers may offer the biodiesel industry its nearest term opportunity for significant additive plant oil supplies. Historically, corn oil has not been a viable biodiesel feedstock due to its relative high cost and high value as edible oil. In current dry grind processes, the corn oil essentially passes through the process and remains in the resulting distillers dry grains with solubles (DDGS). Ethanol firms are investigating fractionation technology to remove corn germ (the portion of the corn kernel that contains oil) prior to the ethanol process. Furthermore, some ethanol plants have either began construction or announced their intent to employ technology to remove the remaining vegetable oil from dried distillers grains, a co-product of the ethanol process. In addition to the various extraction technologies, the quantity of corn oil could also be increased in the long term by producing more high-oil corn varieties.

All of these technologies could add to the biodiesel raw material supply in a meaningful way. Corn oil could help to meet feedstock market demand in two ways. First, edible corn oil could displace other edible oils that could then be diverted to biodiesel production. Second, non-edible corn oil could be used directly for biodiesel production. For example, reaching the federal renewable fuel standard goal of 15 billion gallons of ethanol production in 2015 could generate nearly 400 million gallons of vegetable oil if only one-half pound (less than one third of the potential oil) was extracted from each bushel of corn.

[7] http://www.uscanola.com/index.asp?Type=B_BASIC&SEC={7719E6F7-D189-4CD4-870A-2A866A0D3A7F}

Several ethanol plants have invested in de-oiling technology, and the U.S. Census Bureau initiated coverage of corn oil in their m311k surveys in June, 2008.

Expanded Domestic Soybean Processing
Although highly dependent upon processing economics and domestic demand, vegetable oil supplies could be significantly increased through expansion of the U.S. soybean processing industry. Slightly more than 1 billion bushels of soybeans were projected by USDA to be exported in the 2008 marketing year. If processing capacity were expanded from market signals, more vegetable oil would be available in the U.S. market. Processing an additional one billion bushels of soybeans is the equivalent of 1.5 billion gallons of biodiesel.

Brown Grease Supplies
As reported in, *Statewide Feasibility Study for a Potential New York State Biodiesel Industry, May 5 2004*, brown grease is collected from grease traps installed in commercial, industrial, or municipal sewage facilities to separate grease and oil from wastewater. This 2004 study utilized estimates by Wiltsee that annual production of trap grease averages an estimated 13.37 pounds per person. In the Wiltsee study, he indicates, "Data collected on grease trap wastes are subject to inherent inaccuracies because this material can include a significant amount of water and other materials mixed with the grease…. In all cases, a best effort has been made in this report to adjust grease trap resource data to include only the grease, and to exclude water and other materials that may be present." Assuming that 95 percent of the material collected was lipid, more than 475 million gallons of biodiesel could be produced from brown grease generated in the United States.

Photo by: Joel Rose

Summary of Near-term Feedstock Supplies
Although many opportunities exist for new feedstocks for biodiesel production, it is relatively clear where near term supplies will be generated. Approximately ¾ of a billion gallons of soybean oil should be available for biodiesel production in 2012, and higher oil content oilseeds such as camelina and canola can add more than 200 million gallons of feedstock supplies (refer to table 1). Although lacking a supply response, animal fats and yellow grease can have a significant impact on biodiesel production; potentially adding more than 400 million gallons of production by 2012. If 400 million gallons of feedstock are realized from U.S. ethanol plants, more than 1.8 billion gallons of feedstock would be available for biodiesel production by 2012.

More difficult to quantify are opportunities that may add even greater amounts of feedstock by 2012. These sources will be highly dependent upon commodity economics, market forces, and global policy. Questions that will have to be answered include:

- What percent of vegetable oil exports may be diverted to biodiesel production?
- Will economics dictate expansion of the U.S. crushing industry and divert exports of raw seed to biodiesel production?
- Will processing economics promote expansion of higher oil content soybeans?

- What impact will imported feedstocks such as oilseed palm, South American soybean oil imports, and new imports such as jatropha have on U.S. biodiesel production?
- Will acres in the Conservation Reserve Program be re-enrolled or will acreage be released and available for commodity production?

Table 1. Estimated Feedstock Supplies for the Production of Biodiesel in 2012

Feedstock Source	*million gallons*
Soybean Oil	780
Animal Fats & Yellow Grease	410
Expansion of Camelina Acreage	116
Expansion of Canola Acreage	100
Corn Oil from Ethanol Plants	400
Total near-term sources	**1,806**
Additional near-term feedstock opportunities:	
Diversion of soybean oil exports (maximum potential)	300^
Expanded U.S. oilseed crush (maximum potential)	1,500^
Increased oil content in soybeans	240^
Imports of vegetable oils (palm, jatropha, SBO)	*
Brown grease (maximum potential)	475
Additional potential near-term sources	**2,515**

** Variable - dependent upon market forces and global policy*
^ The extent to which these sources contribute to feedstock supplies will be dependent upon processing economics.

Should conditions prove favorable, more than 4.3 billion gallons of feedstock may be available for biodiesel production. In addition to these highlighted opportunities, several new feedstock sources that will be discussed in the next section could prove to be equally important for future biodiesel growth.

Future Contributions by New Feedstock Sources

The current feedstock supply situation has sent numerous signals to the market to invest in new technologies and methods to increase raw material supplies. Investment in new, non-edible raw materials sources such as algae, jatropha, mustard, pennycress, and halophytes continues at an aggressive rate. Significant volumes of feedstock may also be realized from sources such as high oil corn or oilseed production on acres expiring from the conservation reserve program. Summary information on some of these sources is provided in the following pages.

<u>Algae</u>

Lipid (fat) production from algae holds much promise for the biodiesel industry. Microalgae are microscopic aquatic plants that carry out the same process and mechanism of photosynthesis as higher plants in converting sunlight, water and carbon dioxide into biomass, lipids and oxygen. However, algae production does not require fresh water or arable land used for cultivation of food crops.

Large-scale production of these algal lipids is still a few years away, but many companies and universities are working to unlock the potential of these single-celled plants, which can contain up to 50 percent oil by weight and double their numbers in a single day. Once realized, oil yield per acre is expected to be the highest of any triglyceride source currently available. Yield projections in the medium term are estimated to range from 2,000-5,000 gallons per acre.

There are multiple algae production paths that are being pursued: open ponds, photo bioreactors, and heterotrophic growth. The open pond method involves growing the algae in open ponds of water, much like it grows in nature. Open ponds are generally less capital intensive than the other production methods but require a reliable supply of water to replenish fluid lost due to evaporation. The lack of temperature, weather, and algae species control can decrease yields from their theoretical potential.

Closed loop, or bioreactor, systems grow algae in a controlled environment using a wide variety of production processes like plastic bags, tubes, or fermentation reactions. Closed loop systems provide the advantage of additional control over seasonal temperature changes, evaporation losses and contamination by undesired algae strains. However, the capital costs of bioreactors tend to be higher than for open pond systems.

Locating algae processing plants strategically can add to their efficiency. For example, locating algae facilities next to carbon producing power plants or manufacturing plants could allow for sequestration of CO_2 for use in growing the algae, which needs the CO_2 for photosynthesis.

Ultimately, algae production represents an enormous opportunity for biodiesel producers. However, obstacles remain and commercial production is assumed to be at least five years away.

<u>Halophytes</u>

Many land areas are presently not arable because freshwater is lacking, the soils are naturally saline, or the soils are salty as the result of previous agricultural practices. Many of these areas have abundant saline water available either as surface or ground water. Halophytes are plants that can either survive or thrive in a salt or brackish water environment. Examples include salicornia, an annual salt-marsh plant with an oil content of 15 to 35 percent, and seashore mallow, a perennial which grows on coastal marshlands or inland brackish lakes and has an oil content of 18 percent. The oil from salicornia is similar to safflower oil and seashore mallow to that of cottonseed oil. Halophytes represent a non-edible feedstock source that would be grown on acres not currently being utilized for edible production.

Salicornia is reported to be tolerant of salt levels up to twice that of seawater, has more than six years of field trials in Mexico, and could generate more than 80 gallons of oil per acre for biodiesel production.

Seashore mallow is a novel salt-tolerant perennial crop derived from a salt marsh plant. With an oil content of approximately 18 percent and residual meal that contains 30 percent protein, this crop can be grown on saline land and produce vegetable oil on underutilized or non-arable land. As reported by researchers at the University of Delaware, seashore mallow has a productive life of about a decade and the oil is very similar to cottonseed oil in fatty acid composition. There are few reported insects or diseases that impact the crop. Due to limited breeding efforts, yields of seashore mallow are low compared to other oilseeds. Researchers envision at least four ways that seashore mallow may fit into agronomic scenarios:

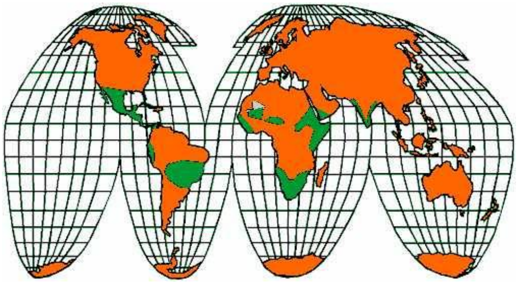
- Grown on salinized farmland;
- Grown on dry farmland with brackish water wells;
- Grown on sandy coastal deserts; or
- Grown on farmland or aquatic ecosystems in transition.

Seashore mallow has been evaluated in more than four years of field trials in the Delaware Coastal Plain and could generate more than 30 gallons per acre of oil for biodiesel production.

<u>Jatropha</u>

Jatropha is a small but versatile bush/tree from the Euphorbiaceae family. The tree flowers and produces clusters of about 10-15 fruits with a seed containing high concentrations of oil. *Jatropha Curcas L.* is gaining a lot of attention as a potential feedstock for biodiesel production due to its high oil content and ability to grow in less than ideal conditions. However, harvesting and logistical challenges have kept the plant from being grown in large scale production in places where there is not an abundance of low cost labor.

Historically, most of the Jatropha has been grown in tropical areas including Africa and Asia, especially India. More recently, it has been grown on most continents around the world. The green shading on the map below indicates the primary areas where Jatropha is grown. These areas are mainly inside the tropics and are not known to have land of good quality.



This low maintenance plant has generally proven to be resistant to local pests under common cultivation practices and can produce seeds containing up to 40 percent oil. While Jatropha is touted as being able to survive in poor soils with very little fertilizer and water, the fruit (and thus oil) yields increase significantly with increased soil fertility and water. For example, adding small amounts of magnesium, sulfur, and calcium have a significant impact on improving yields. Jatropha can survive in areas with annual rainfall of 8-12 inches. In extreme conditions, plants will survive drought by dropping its leaves to reduce transpiration loss. In fact, this resilient plant can survive three full years of drought before it would die. However, fruit production is very low during these drought years. While Jatropha is most commonly grown in low altitude regions that are relatively warm, it can grow at higher altitudes but can only handle a slight frost.

Since Jatropha can grow in arid areas that are not suitable for traditional grain crops, there could be a potential market for growing Jatropha in portions of the United States. Such areas could include much of the dry southern states including Arizona, Texas, and New Mexico, and other arid grounds. Literature has also suggested that Jatropha could grow very well in Florida, California, Alabama, Mississippi, and Louisiana. In order to be economically viable in these states, Jatropha would need to be grown in a manner that does not compete with existing crops or alternative competition such as urban sprawl.

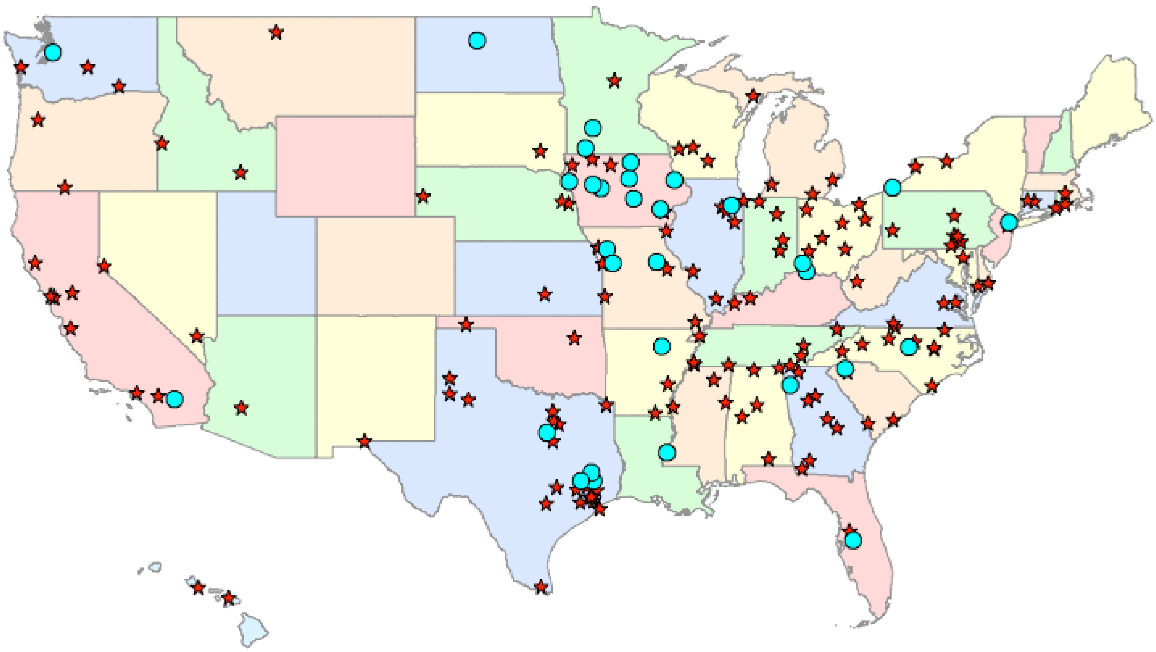
High Oil Corn

In the early 1990s the production of high oil corn was on the rise for its enhanced feed value. However, production has since declined due to yield drag, pollination challenges, segregation costs, and handling issues while offering only moderate added value. If the technologies described above prove to be economically viable, then growing high oil corn may make sense economically. This could drive demand such that seed companies would re-focus efforts on high oil varieties to address production challenges. Traditional corn has oil content of about 3.5 percent. High oil varieties have oil yields of about 6.8 percent.

Biodiesel Industry Capacity

In addition to questions related to feedstock supplies, policy requiring specific quantities of biodiesel also brings industry plant capacity to the forefront. There are presently 176 companies that have invested millions of dollars into the development of biodiesel manufacturing plants and are actively marketing biodiesel. The annual production capacity from these plants is 2.61 billion gallons per year. It is important to note that production capacity differs from the actual number of gallons sold. Between 25 and 50 million gallons of production capacity currently exists in California, and approximately 125 million gallons of capacity exists in Washington and Oregon.

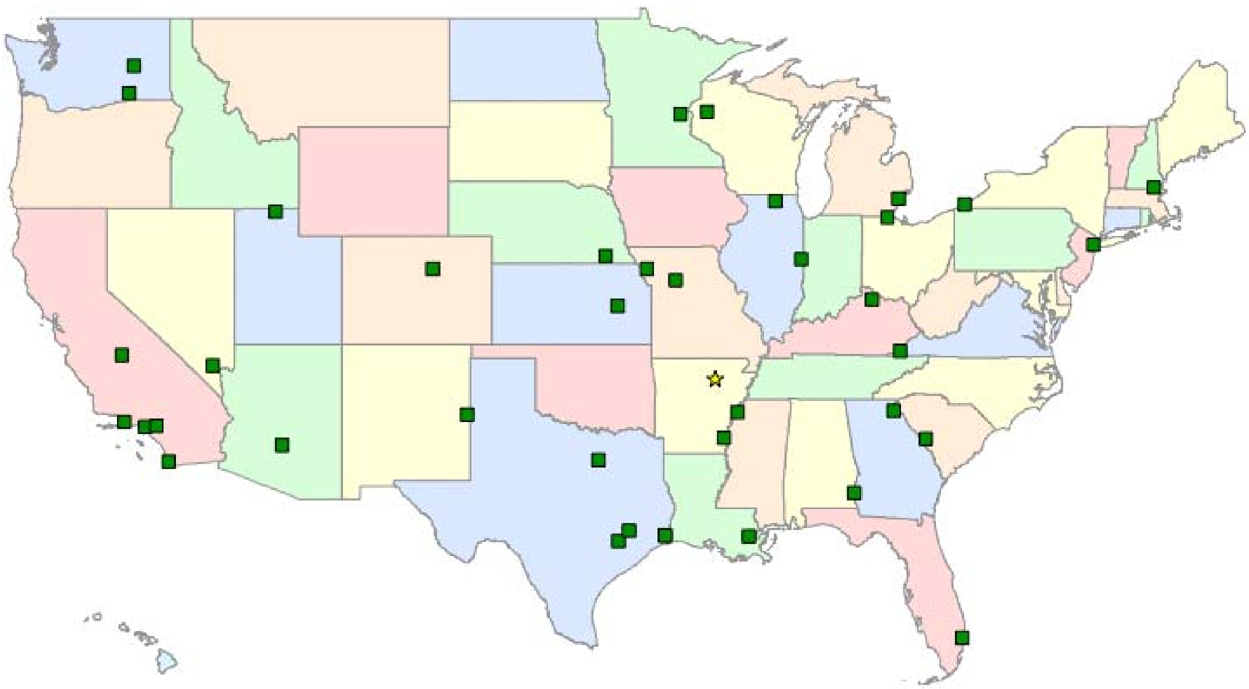
Figure 1. Biodiesel Production Locations, September 2008[8].



Thirty-nine companies have reported that their plants are currently under construction and are scheduled to be completed within the next 12-18 months. One plant is expanding their existing operation. Their combined capacity, if realized, would result in another 849.9 million gallons per year of biodiesel production.

[8] www.biodiesel.org

Figure 2. Biodiesel Plants Under Construction & Expansion, September 2008[9].



Neither equity investment in plant capacity nor feedstock supplies represent a constraint in the marketplace for production of sufficient quantities of biodiesel to meet the RFS2 requirements for biomass derived diesel.

Conclusion

The biodiesel industry has experienced rapid growth in production capacity in the last five years. This rapid expansion has lead to competition for feedstock among biodiesel producers and the need for biodiesel plants to develop the capability to process a wide variety of feedstock to remain economically competitive. Consequently, efforts are underway to increase the supply of traditional plant oils and animal fats and to develop nontraditional sources. These efforts are also seeking to increase feedstock supplies while being environmental responsible.

Demand for biodiesel is expected to continue to grow. However, the anticipated expansion of existing feedstock supplies in the short term has the potential to produce at least 1.8 billion gallons of biodiesel by 2012. If the development of longer-term feedstock prospects is realized, the potential supply of biodiesel feedstock will keep pace with future demand for biodiesel.

[9] www.biodiesel.org