Energize Missouri: Algae-Based Renewable Energy Study

Task D
Opportunities for Missouri to be a Leader in Algal Biofuels' Products and Services

Final Report

For
Missouri Technology Corporation

MRI Project No. 110754.1-D

August 8, 2011

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For
Missouri Technology Corporation
301 West High Street
Jefferson City, Missouri 65102

Attn: Jason Hall

MRI Project No. 110754.1-D

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Preface

This report was prepared for the Missouri Technology Corporation under a grant award to MRIGlobal and entitled "Energize Missouri: Algae-Based Renewable Energy Study" signed by Mr. Jason Hall and dated February 28, 2011. Work was initiated in accordance with a work plan submitted and approved on March 11, 2011. The project team includes members from MRIGlobal, Washington University in Saint Louis, and the University of Missouri, Columbia.

The objective of the grant is to produce a study to help define the development and commercialization of algae as a fuel source that would be a valuable adjunct to the state energy plan. The study would emphasize the potential benefits to the state economy that a commercial algae industry could bring, opportunities for Missouri to become a leader in such an industry, and the policy steps and collaborations that the state could initiate to strengthen Missouri's leadership in this area. The study is divided into seven tasks plus a final report. This report is the results of Task D, which sought to identify opportunities for Missouri to be a leader in the algae-based biofuels industry.

The Task D study was authored by Greg Karr of MRIGlobal as Principal Investigator. The authors wish to acknowledge contributions by Jay Turner of Washington University in St. Louis (WUSTL), Bill Babiuch, Stanley Bull, and Thomas Grant (MRIGlobal). We also gratefully acknowledge conversations with Richard Sayre (Donald Danforth Plant Science Center), Tom Verry and Shelby Neal (National Biodiesel Board), and Richard Axelbaum, Robert Blankenship, Raymond Ehrhard, Mark Henson, and Himadri Pakrasi (WUSTL).

MRIGLOBAL

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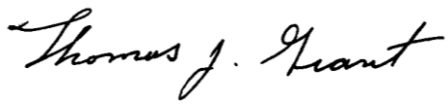

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Section 1.
Introduction

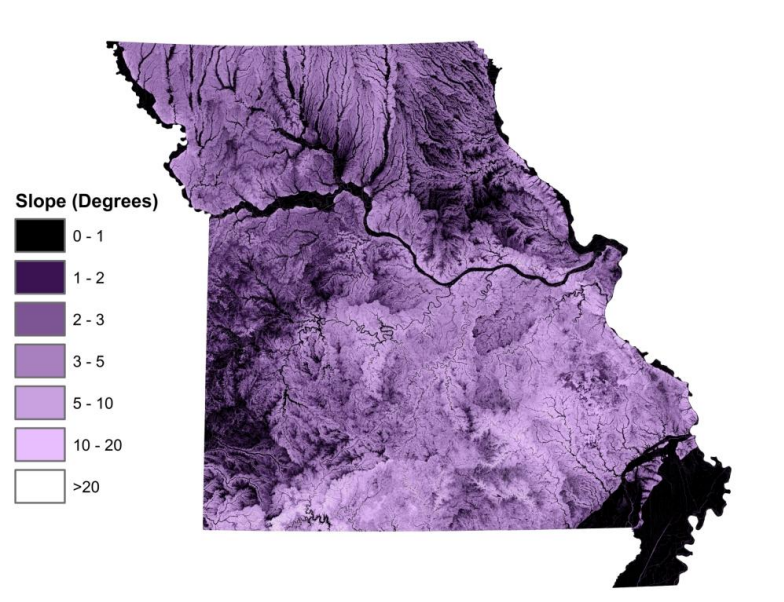
The Task D report identifies opportunities for Missouri to be a leader in supplying products and services and implement commercially viable production systems for algae-base fuels. The approach used to identify these opportunities was to evaluate the findings from Tasks A, B, and C to identify the algae biofuel and other product market segments that hold the greatest opportunities for Missouri to be a leader. This involved assessing the state's academic and industry assets as well as the availability of critical algae natural resources. An overview of the trends and current state of the energy, biofuels, and algae segments were provided in Task A. Missouri's assets were categorized into three major groups in Task B, (1) research and development activities, (2) industrial assets, and (3) resources for algae production. Task C investigated the algae activities in other states and offered a comparison to Missouri.

The following discussion is structured as a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. The structure of the analysis will allow the expansion of asset discussion (Task B) to determine the significance of the asset and how new opportunities can be derived. The point of view of this study is the state of Missouri as a whole, not a specific industry or interest group. Threats are not specifically part of the following discussion. In the foreseeable future the growth of an algae industry is not viewed as a Threat to any existing Missouri-based business segments. The most significant possible threats for Missouri regarding algae are the risks of making un-informed decisions that may have a greater chance of failure or the threat of non-action and being left behind in an emerging market area. The identified opportunities are based on the identified assets and predicted market trends found from this and other available research efforts.

A specific discussion is provided in the highlighted insets regarding the potential for an algae production industry in the Missouri Bootheel region. This discussion is separated for the rest of the text because of the unique combination of resources available in the region. The Missouri Bootheel is a region within the state that possesses unique opportunities for algae production that few locations in United States can claim.

The Missouri Bootheel

The Missouri Bootheel is an area of the state that may have a unique opportunity for large scale algae production. The Bootheel consists of the counties of Dunklin, New Madrid, and Pemiscot. For the purpose of this study, the term will include the entire southeastern lowlands province, including all or parts of Ripley, Butler, Stoddard, Mississippi, Scott, Bollinger, and Cape Girardeau counties. The figure below shows the degree of slope for the state. The large dark area in the Southeastern corner of the state is the “Bootheel” and shows an area of approximately 3,000 square miles with less than 1 degree land slope which makes it a potential location for large scale algae production.



The area was formally the flood plain between the Mississippi and the St. Francis rivers, now controlled by levees and canals. From the Mississippi River going west, the land raises almost imperceptibly for almost 40 miles until a slight rise is encountered at a north-south ridge called Crowleys Ridge. At 50 miles from the Mississippi River, the land starts to rise to meet the Ozark Escarpment, and it abandons its lowland character. For almost 100 miles from Cape Girardeau to the southern Pemiscot border, the elevation difference is only 70 feet. Large continuous acres of flat land is essential to keep the construction and capital cost of the algae production systems low.

Section 2.
Strengths

2.1 Academic Research and Development Expertise

Missouri's collection of industry leading algae research institutions and universities is a dominant strength for the state. The in-state algae R&D assets are only rivaled by a few other locations in the United States. Florida and Southern California are the primary hotbeds in the algae research and development space. Arizona, New Mexico, West Texas, and Hawaii are the primary locations for demonstration facilities and potential commercial facilities, but have less of a presence of R&D activities. The Missouri institutions involved in algae related R&D activities are presented and discussed in Section 2 of Task B.

These intellectual and expertise assets have the potential to be highly valued and in demand with a growing algae industry across the U.S. and worldwide. Algae companies will need this expertise to enter and succeed in the market and employers will need a steady supply of highly trained personnel that will be generated by the educational missions of these institutions. This creates an opportunity for research and consulting contracts to provide a steady revenue stream into the state. While Research and Development does not create immediate large employment numbers, they are high-tech positions and they allow Missouri to maintain the reputation of being on the leading edge in the algae industry.

2.2 Industrial Manufacturing and Engineering

Each side of the state of Missouri has a strong industrialized urban center that has ample capacity to support new and emerging algae business segments. As the industry emerges, different algae market segments will show signs of new opportunities. The light manufacturing and construction companies will be well suited for quickly developing prototypes and systems and the required design generations that will follow. The areas of algae harvest, dewatering, drying, and oil extraction will benefit the most from the support of light industrial equipment capabilities. To date, there are very few equipment companies working to support an algae industry that currently does not exist. The risk is too high to predict when and if the algae industry will begin a significant level of production build-out. It will be important that potential equipment manufacturing and supplier companies have a reliable source of information to draw from when they want to learn more about the algae industry.

Regardless of the production approach taken, algae cultivation and harvest will primarily consist of efficiently moving large amounts of water. Engineering and construction firms working in the areas of wastewater treatment facilities will be well positioned to support the build out of the algae production segment. Two world class, leading engineering and design firms are headquartered in Kansas City. Burns & McDonald and Black & Veatch have extensive experience in large water projects and electrical utility power plant construction.

2.3 Biofuel Conversion Facilities and Companies

There are nine biodiesel plants in Missouri and six operating ethanol plants. While the proximity of these biodiesel facilities may make an attractive environment to co-locate algae production and oil extraction facilities, it is not a necessity once the algal biomass is harvested/dewatered and dried or the oil is extracted. The algal oil or biomass will be of significant density such that it can be efficiently transported similar to grain or vegetable oil. Therefore when algal biomass and oil production reach commodity levels, Missouri biodiesel operators will only have a slight regional advantage in transportation efficiency, but overall the same access to the commodity feedstock supply as other biodiesel facilities.

The St. Louis area is also home to two major biofuel industry participants. Bunge North American Headquarters, located in St. Louis, is the second largest soybean processor in the U.S. and the largest canola processor in Canada. Bunge oilseed processing facilities and expertise is a substantial asset that could be utilized to bring algae processing to full commercial scale. Abengoa Bioenergy Corporation is also headquartered in St. Louis. Abengoa is primarily an ethanol production company; however, its expertise in biofuel manufacturing and distribution is an asset for the state.

Another significant asset to the state of Missouri is a fuel distribution terminal located in St. Louis. The Center Point Terminal is owned and operated by Center Oil Company, which distributes gasoline and other refined petroleum products throughout the U.S. by pipeline, ship, barge, and truck. Schaeffer Manufacturing is an oil-lubricant formulator and marketing company also in St. Louis. Schaeffer maintains several soy oil based fuel additive, hydraulic oils, and lubricant products. These product lines have the potential to utilize alternative sources of vegetable oils such as algae.

2.4 Nutrient Resources

Inexpensive sources of nitrogen and phosphorous will be required by all algae production facilities. It has been shown by various researchers that algae production is very efficient at removing low levels of these and other nutrients from large volumes of water. Some wastewater treatment strategies use algae ponds or a wet-lands system as a final water filter before being fully released downstream. The convergence of major watersheds supplied by highly fertilized farm land and the significant amount of Concentrated Animal Feeding Operations (CAFOs) creates a significant supply of these underutilized and often wasted nutrients in Missouri. Figure 1 shows the locations of the permitted CAFO in Missouri. There are high concentrations of poultry farms in the Southwest corner and to a lesser extent a cluster in central and southeast Missouri. Managing the manure of these CAFO's has become an environmental challenge as more farms are operated in close proximity. For a growing and full scale algae production industry, these point sources of concentrated nitrogen, phosphorous, and potassium (NPK) could be a value able input. Raw manures have a high Chemical Oxygen Demand (COD) and bacteria and pathogen loading which will limit the direct use as a nutrient source for algae. Additional processing will be required to transform the manure into a safe, usable and transportable algae nutrient product. Manure processing will need to be developed alongside algae nutrient

utilization studies to confirm the effectiveness of the product. Thermophilic anaerobic digestion is a possible solution to reduce the COD and pathogen levels in raw manures.

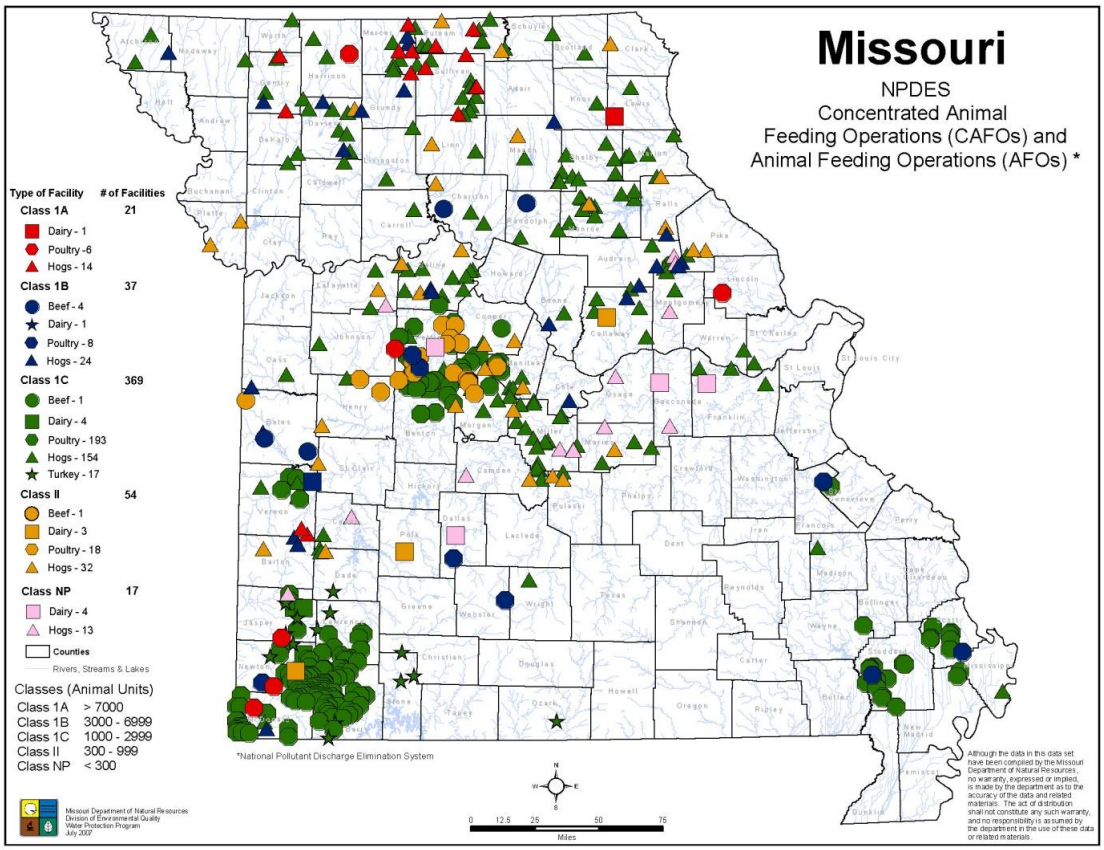


Figure 1. CAFO Locations as of July 2007, Source Missouri Department of Natural Resources

2.5 Water Resources

Missouri has strong water resources that could be utilized by an algae production industry. The algae industry will struggle with the availability of water in areas of the United States, which have available flat land resources and high solar intensity. These target areas of west Texas, New Mexico, Arizona, and southern California, the Sunbelt, have the land and solar resources but have significant water deficiencies. Missouri's water resources from its vast waterways, watersheds, and reservoirs create a valuable resource for algae production. Figure 2 shows the major waterway and bodies of water in Missouri. The entire eastern border is the Mississippi River, the Missouri River cuts across the middle of the entire state, as well as the many large reservoirs that populate the southern part of the state. Not all these waterways are going to have the capacity to support a localized algae industry or be positioned near suitable land for algae production; however, it does present a high number of target areas. Algae's ability to utilize dilute nutrients from water also allows water to be used from non-potable sources and provide an increase in water quality after use.

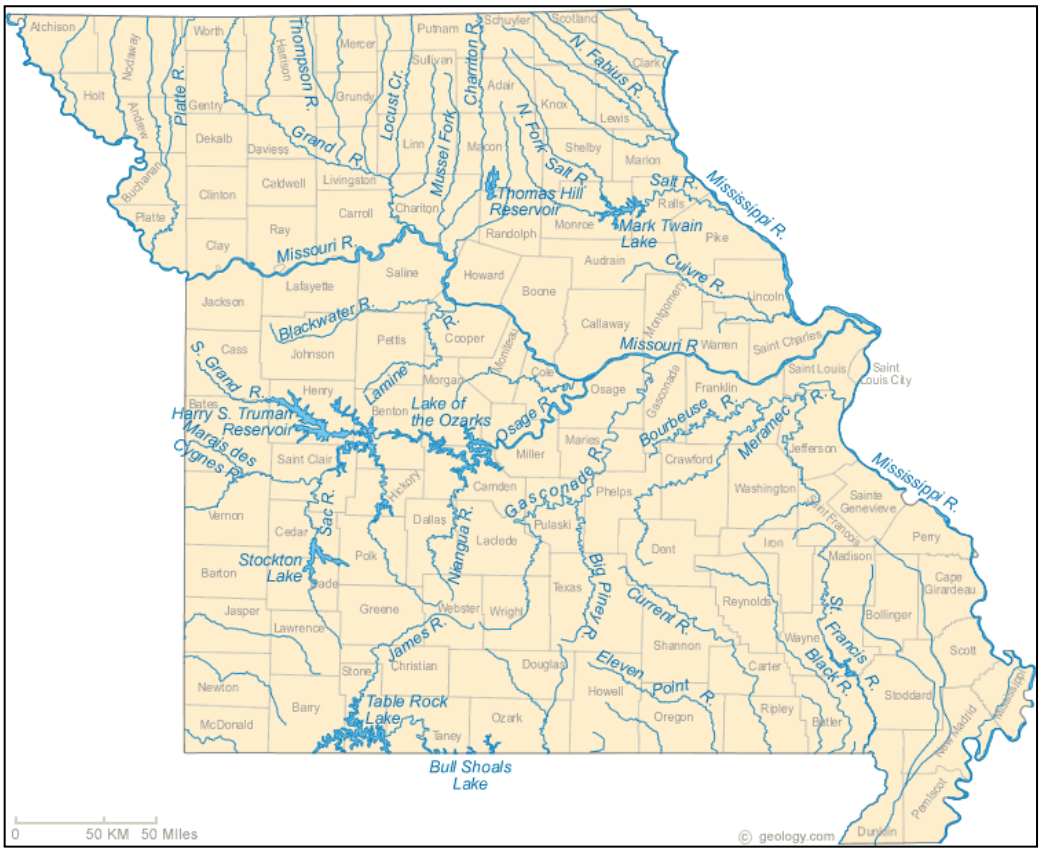


Figure 2. Missouri Waterways and Reservoirs, Source U.S. Geology.com Website

The Missouri Bootheel Strengths

Land: Large contiguous acres of low slope land, as discussed earlier, is critical for commercial scale algae production facilities. Geographically referred to as the Mississippi Alluvial Plain, the Bootheel lowlands is primarily rural cropland. Land values have increased for the last several years along with economics of farming. Last year the average sale price for farm land in the region was about $4,000 per acre. This will be higher than dry land areas of the Sunbelt, but is reasonable with the other resources available.

Water: The availability of water will be one of the key factors for algae production at a commercial scale. The Bootheel area contains the greatest volume of ground water per unit area than almost any other part of the United States. The Missouri Department of Natural Resources (DNR) estimates that 76 trillion gallons of water is contained in the groundwater of the Bootheel region. Several aquifers are present under the Bootheel lowlands, and are productive to various degrees; however, the Southeast Lowlands alluvial aquifer is the most prolific and widely used. This shallow aquifer underlies 92% of the Bootheel lowlands, and wells in the region typically produce 1,000 to 2,000 gallons per minute. At present, agriculture utilizes 287 billion gallons of water annually for irrigation with no apparent drawdown. Nearly 50 years of measurements has shown no decline in the aquifer, which perhaps is recharged by the 50 inches off annual rainfall in the region. Ground water is very shallow in the area, and ranges from 4 feet deep near the Mississippi River to up to 20 feet deep further to the west. The sustainable water from wells, reservoirs, and rainfall would appear to eliminate water use as an issue for algae production.

Solar Energy: Days with direct sunlight averages about 60% annually, and solar radiation data issued by NREL indicate 4.5 to 5.0 kWh/m^2/day average. This solar energy is adequate for algae growth, but will need to be studied to produce reliable algae growth models.

Nutrients: There is a cluster of CAFO's located just to the north of the lowland area. These CAFO's have the potential to supply low cost nutrients for algae production.

Climate: Temperatures in the region are relatively moderate. The mean annual temperature is 60 degrees Fahrenheit, with summer average highs in the low 90s, and mid-winter average lows in the high 20s. Although the climate is mild and contains days in the 40s every month of the year, the region can experience some below freezing temperatures in 3 months of the year.

Carbon Dioxide Source: There are two coal-fired power plants located in the Bootheel near Sikeston and New Madrid. These power plants are potential sources for large quantities of CO_2 and waste heat that could be utilized by large scale algae production.

Location: The area is bordered by the Mississippi River which provides access to efficient transportation of bulk biomass. Bunge maintains an oilseed crushing facility in Cairo, Illinois, which is just across the Mississippi River. The economy of the region is sluggish and the annual income is among the lowest in the state. Farm labor is available and wages are low. New development for an algae industry could provide a welcomed economic influx to the region.

Existing Biodiesel Infrastructure: Three Biodiesel production facilities are located in the Bootheel. Global Fuels, Dexter, Missouri; ME Bioenergy, Libourn, Missouri; Natural Biodiesel Plant, Hayti, Missouri combine for 13 million gallons of annual production capacity.

Section 3.
Weaknesses

3.1 Algae Start Up and Investment Presence

There is not a strong presence of algae related start-up or investment backed development companies located in Missouri. These types of investor-backed ventures have focused their efforts and investments in Florida and the Southwestern United States. Missouri is not thought of as a hot bed of entrepreneurs in the algae industry such as states like Florida, Texas, New Mexico, Arizona, and Southern California. There are algae companies and developmental efforts being conducted in various other locations around the U.S.; however, these are geographically spread out and are not able to use one another to help create an industrial critical mass. An entrepreneurial presence alongside strong academic and research institutions can help create a synergistic effect, which attracts the investment communities into a specific region and thereby attracting outside investment into the state. The strong academic and research institutions in the state can provide the intellectual and personnel capital to seed an emerging entrepreneurial spirit. However to date, there does not appear to be a strong algae related entrepreneurial community in Missouri.

3.2 Algae Production

Currently, there are no significant algae production facilities in the state. To date the most common algae cultivation facilities are producing algal biomass at fish farms for on-site use or high value pharmaceutical and nutraceutical products. These types of facilities are primarily located in the Southeastern U.S. and California near existing aquaculture operations. There is a measureable aquaculture industry in Missouri, with 47 members registered with the Missouri Aquaculture Association. However, most of these businesses appear to be small fish farms, which supply local stocking and recreational fishing supplies, not high production fish farms that utilize on site algae production for fish meal.

3.3 Large Tracks of Available Flat Land

The key point of this discussion is what is meant by large. When biofuel development companies project algae production as a biofuel feedstock, full scale production is planned to cover thousands of contiguous acres. This level of scale at a single site is optimal to adequately utilize algae harvesting, dewatering, and drying equipment and processes. This level of production may be a challenge for Missouri and only possible in a few regions of the state, such as along major river valleys and the Missouri Bootheel. However, this does not mean that smaller scale algae production is an area Missouri has no role or opportunities. Algae production at reduced scale for higher value products may fit into the diverse topography. Mid scale algae production (hundreds of contiguous acres) could provide significant levels of algal biomass for

animal feeds, fish meal, nutraceuticals, and cosmetics. Algae production for each region must be evaluated on the basis of all the required inputs, resources and available markets.

The Missouri Bootheel Weaknesses

Land: The build out of significant algae production will displace acres currently in agriculture production. The primary agriculture in this area today is cotton, rice, and soybean farming. This effect will be the same as almost any other region in the U.S., which has the natural resources available to grow algae. One perspective to keep in mind is that algae production is farming. Water, sunlight, and fertilizer are used to grow and harvest a plant biomass material. Therefore, any land that is converted to algae production is displaced from one type of agriculture to another.

Water: Water is readily available in the Bootheel; however, there will also be an elevated risk of floods. The area uses a network of levees and canal to control flooding. These structures are successful most of the time; however, there are years in which crop damage and loss occurs. There would be added risk by locating the significant capital infrastructure, needed for algae production, in a floodplain.

Solar Energy: Days with direct sunlight averages about 60% annually. Cloud cover can reduce solar radiation and if significant, algae growth rates. This would be viewed as negative when compared to the Sunbelt region, which receives direct sunlight over 80% annually. However, it is unknown the percent (if any) reduction this would cause on overall algae growth rates.

Climate: Strategies will be required to moderate the temperature extremes. However even these extreme are relatively small and have the potential to be solved by minor efforts and minimize any reduction in algae growth rates.

Section 4.
Opportunities

4.1 Educational and Professional Services

Missouri has the opportunity to maintain its leadership role as a cutting edge algal research hub. This role could be even more critical and prominent if a significant algae industry build-out occurs in the south central and the Midwest United States. Building off the significant investments made in the before mentioned research institutions, world class algae expertise will attract leading students, faulty, business entrepreneurs and investors to the area. This expertise will be sought after by the algae industry and value returned to the state by federal research grants, contract research and consulting, private investment, and job creation by industry growth.

The activities and advancements of research institutions will generate a level of commercial spin-outs in the area. The research activities in Boston and the California Bay Area have generated many technology-driven start-up and investment backed private ventures. New ventures will chose to locate near well established research hubs to take advantage of the cutting edge R&D programs at the institutions and the associated talent pool for growth potential. This is an opportunity for Missouri to assist new ventures in the algae industry to help build off the foundation of these leading research institutions.

4.2 Nutrient Management and Resources

The growth of large scale algae production in Missouri and across the U.S. may present a unique opportunity for the waste management strategies of CAFOs. Abundant sources of low cost nitrogen, phosphorous, and potassium (NPK) will be critical for commodity scale algae industry. The CAFO's represent a point source for these nutrients and could provide another waste management option. The opportunity with nutrient resources regarding algae has a notable comparison to the interest the coal power industry had with algae less than a decade ago when it first re-emerged as an alternative feedstock for renewable fuels. Coal powered utilities were facing an incredible waste disposal challenge regarding carbon dioxide. Carbon dioxide is generated in large quantities with no further use and released to the environment. With growing calls for greenhouse gas reductions and a possible carbon-based cap and trade legislation pending, the coal industry's focus turned to algae as a possible solution for CO_2 mitigation. The interest and thereby investment proved to be short lived as the algae industry was years away from operating at any significant scale compared to a coal powered electrical plant and legislated carbon cap and trade stalled. This illustration is not meant to discourage a comparison to the CAFO's current waste disposal challenge, but to be used as a guide and show how the situation is different. The manure management challenges faced by CAFO's have several key parameters that could allow a better alignment with mid-scale algae production.

- Smaller, more distributed point sources as compared to the CO_2 release at power plants. Flue gases exiting a coal stack are of the scale of millions of tons of CO_2 per day and in a high volume gas state. While the volume of nutrients exiting a CAFO is also

significant, they are at a farm scale. This will allow the scaling of the two facilities to better align and a better likelihood of success.

- It is possible to process, concentrate, and transport the nutrients to algae production facilities in the region or across the U.S. The known technologies to concentrate CO_2 are cost prohibitive as well as any methods for storage and transportation. Therefore, for an algae facility to have a significant impact in regards to CO_2 mitigation had to be extremely large scale and on-site in close proximity to the power plant.

An emerging algae production industry may provide an increase demand for low cost organic NPK sources that in turn would create a market and outlet for the waste streams of CAFO's. If the manures can be converted to safe, concentrated, and effective nutrient source for algae growth, the market potential would be nationwide.

4.3 Algae Production for Nonfuel Markets

An algae industry and market report (*Algae 2020*, 2010) discusses the growth of commercial algae production will begin with high value, low volume product markets. Market level volumes are expected to begin production in 2011 to 2012 in the areas of pharmaceuticals, specialty chemicals for cosmetics and high value nutracueticals. As production efficiencies increase and the costs of production go down, products for larger markets, yet lower value, will be targeted. These markets are expected to be specialty food additives, healthy oils high in Omega 3, 6, and high value animal and fish protein additives. *Algae 2020* predicts production levels and costs to be at a level to start entering these markets by 2015.

The production of algae for smaller niche markets could prove to be a best case scenario for the state of Missouri to enter into algae production. High value products in the pharmaceutical, nutraceutical, and cosmetics markets will provide the greatest value; however, these small markets could quickly become saturated with a significant production build-out. Larger markets such as livestock, poultry, and fish feed additives provide additional volume capacity as well as good market access being in close proximity to livestock feeding operations. Some algal species produce biomass with high protein content (30% to 40%) and can do so without sacrificing growth rates.

4.4 Climate and Natural Resources for Algae Production

Missouri is not a leading target area for commercial scale algae production facilities for biofuel feedstocks in the U.S. This is most likely due to the lack of large contiguous tracks of flat land and it is not thought of as an area with intense solar resources. The primary inputs for algae production are solar energy, water, nutrients, carbon dioxide, and available flat land. Water, nutrients and land had been discussed in earlier sections. Missouri's annual average solar intensity is 4 to 5 kWh/m^2/day (NREL, 2008), which is adequate to sustain algae growth. This is not as high as the 6 to 7 kWh/m^2/day in the Southwest U.S., but near the 5.5 to 6.0 kWh/m^2/day in Florida. However, sunlight intensity will not proportionately increase algae growth rates. Algae and other plants reach saturation levels of light and are not able to utilize high levels of

solar energy. Seasonal daylight hour fluctuations will have an impact on daily growth rates; however, these will be predictable seasonal changes.

Temperature fluctuations will also be a factor for algae production in Missouri. Optimal growing temperature for most micro-algae species is between 68° and 75°F (Lavens, 1996). At water temperatures lower than 60°F, growth rates will be significantly reduced (Lavens, 1996). Temperatures above 95°F will kill most algae species and becomes a risk of losing the entire culture instead of only a temporary reduction in production rates. This is a significant danger in closed photobioreactor systems that do not allow evaporative cooling. Potential strategies to maintain acceptable temperature range in Missouri will be to utilize waste heat sources in the winter and a form of evaporative cooling during the summer.

The other inputs for algae production is carbon dioxide. Direct input of a concentrated CO_2 source has been shown to increase algae production under most growth conditions. Missouri has 24 coal powered electric plants and 6 ethanol plants that generate large quantities of CO_2. While integrating a coal plant to algae production presents large scale engineering challenges, it does provide options for target point sources of CO_2 for future development. The CO_2 demands for smaller algae production facilities could be supplied by small stationary power generation facilities, piped in from other sources or supplied by the direct injection of air.

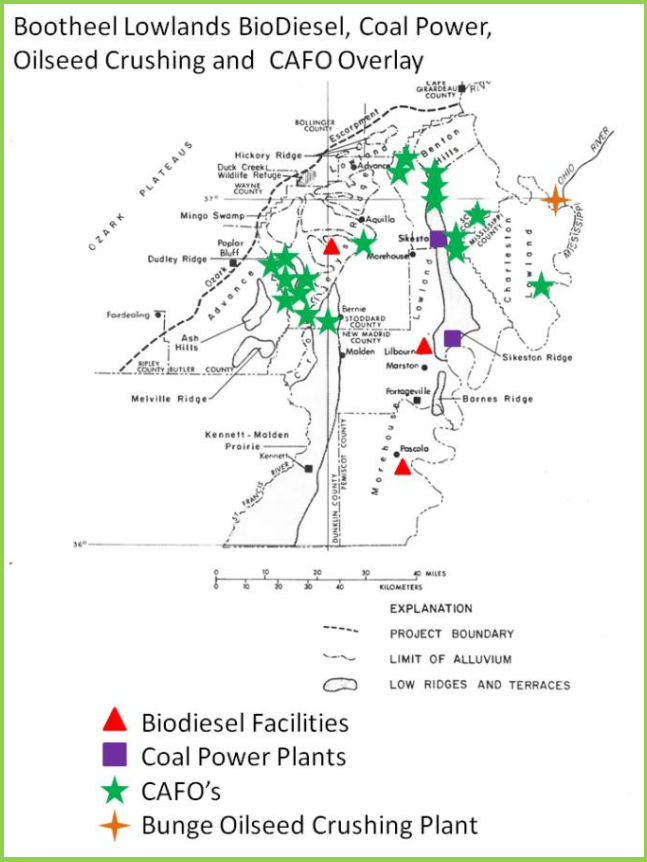
4.5 Biofuels Production

Biofuels and specifically biodiesel will be the last market segment able to significantly capture feedstock from algae production. *Algae 2020* predicts algae production levels and costs will reach biofuels feedstock applications by 2020. For algae oil and biomass to reach commodity levels, an entire production to market to refinery infrastructure for algae must be created. Infrastructure such as storage bins, silos, collection depots, bulk handling equipment, rail transportation, and oil extraction facilities are needed. It is unknown if or to what extent the existing farm commodity infrastructure can be utilized by algae. As algae biomass production levels increase with the early market applications, the bulk handling and future commodity trading of algae biomass will emerge.

There will also be competition for oil feedstocks from an emerging technology referred to as green or renewable diesel. Renewable diesel is a renewable oil hydrogenation process developed by Honeywell UOP and currently in pilot scale production. The process is considered a bolt on process to a traditional oil refinery, and is presented to be agonistic to the source of renewable oils while producing a completely fungible diesel fuel and/or aviation fuel. Existing oil refineries have better access to fuel distribution pipelines and marketing channels than stand alone biodiesel facilities. There will also be processing efficiencies derived from existing oil refinery infrastructure. Therefore, the biodiesel industry will be in a highly competitive environment to secure the additional feedstock supplies.

The Missouri Bootheel Opportunities

The adjacent figure uses a topography map (Luckey, 1985) of Missouri's southeastern lowlands province and an overlay of the existing facilities and infrastructure that could be utilized by an algae production industry. The previous Strengths section shows that the area has the needed natural resources to be well suited of algae growth, abundant water supply, sunlight, and flat land. Although this is a relatively small region, approximately 3,000 square miles, it could be the best suited for commercial scale algae production compared to any area in the United States. There is an oil extraction facility and three (3) biodiesel conversion facilities located within a 40 mile radius. Local CAFO's could provide an NPK nutrient source for algae growth as well as a market outlet for the algae protein meal by-product remaining after oil extraction. These facilities could provide the foundation for a commercial scale algae farm to be successful. This is a unique opportunity for the state of Missouri to be a leader in a highly integrated algae production process.



Section 5.
Conclusions

The growth and build-out of the algae industry holds significant opportunities for the state of Missouri. The four main algae business areas identified are; (1) Research and Development, (2) Equipment Manufacturing and Engineering, (3) Bio-Fuel and Bio-Product Companies, (4) Algae Biomass Production. Missouri has a unique blend of assets in each of these areas except Algae Biomass Production, but has the required natural resources to build assets in the area. Missouri's strengths in the algae industry currently reside in the research and development, large project engineering firms, and Biodiesel conversion facilities areas. Other significant strengths come from the agricultural and agribusiness assets as well as natural resources available to support the area of algae biomass production. The Missouri Bootheel region is a high value target area for algae production in the state and processes all the major natural resources and industrial assets for a highly integrated algae production industry.

Section 6.
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