

Arizona Biodiesel Feedstock Analysis

Version 1.0

December 2008



Desert Biofuels



Technology Ventures Consulting



© 2008 S. Howe, P. Arambula and C. Thompson Jones

This work is licensed under a Creative Commons Attribution 3.0 license

<http://creativecommons.org/licenses/by/3.0/>

Required attribution: "by S. Howe, P. Arambula and C. Thompson Jones for the Desert Biofuels Initiative <http://desertbiofuels.org>"
(or substantial equivalent)

Table of contents

Executive Summary	3
Biodiesel Feedstock in Arizona	4
Waste Vegetable Oil (WVO)	4
WVO Supply.....	4
WVO Collectors.....	6
Where is the WVO going?.....	7
Agricultural Feedstock.....	9
Most Promising Agricultural Feedstock in Arizona	12
Arizona Feedstock Research.....	13
Algae	15
Cyanobacteria	19
About the authors	20

Executive Summary

This report provides an analysis of biofuels feedstocks in Arizona, focusing on (a) waste vegetable oil, (b) region-suitable agricultural feedstocks, and (c) algae. The intent of this report is to gather facts about precisely what is happening in Arizona in connection with these feedstocks, in order to enable regional biofuel producers to make solid investment decisions and to help policymakers who are interested in advancing the regional production of biofuels.

Key data points and conclusions related to waste vegetable oil (WVO) include:

- Over the course of a year, the Phoenix area produces between 6.5 million and 16 million gallons of waste vegetable oil (WVO).
- The WVO collection market is cyclical. As of the fall of 2008, WVO collectors generally were paying large producers for their WVO, at a rate between \$0.25 – \$0.38/gallon.
- Rendering companies and commercial and co-op biofuels producers collect well less than half of the WVO that is generated in the Phoenix area. Biodiesel homebrewers collect a small portion of the remaining available WVO, but the destination of millions of gallons of WVO remains a mystery.
- It seems reasonable to conclude that some of the “missing” WVO is being disposed of improperly, and contributing to costly sewer overflows and blockages. The City of Phoenix attributed 60 sewer overflows and 80 sewer blockages in 2006 to grease and oil.
- Of the “known” WVO, the majority that is collected is reused in animal feed, rather than being processed into biodiesel.
- **There are notable opportunity costs associated with the current situation.** Converting all local WVO to biodiesel would result in substantial environmental benefits (e.g., saving over 100,000 tons of CO₂ from being released into local air per year), but these benefits are not achieved when (a) the majority of local WVO is not reused at all, and (b) the majority of local WVO that is reused is processed into animal feed.

Concerning agricultural feedstocks, it appears that Alfalfa, Cotton, Jatropha, Jojoba, Lesquerella, and Moringa are most promising agricultural feedstocks in Arizona, considering various region-specific variables. There are also a number of crops grown on Conservation Reserve Program (CRP) lands and abandoned open pit mines that show potential for biodiesel feedstock in Arizona. Some of these crops are switchgrass, willow, and hybrid poplar.

Algae and cyanobacteria are particularly promising feedstocks in Arizona. APS led an early, groundbreaking algae effort. Arizona is the home of several promising algae companies (PetroSun, XL Renewables, Diversified Energy, Energy Derived and Desert Sweet Biofuels). Arizona State University hosts two world-class algae and cyanobacteria research efforts, and the University of Arizona also hosts a leading algae program.

Biodiesel Feedstock in Arizona

This report provides an analysis of biofuels feedstocks in Arizona, focusing on (a) waste vegetable oil, (b) region-suitable agricultural feedstocks, and (c) algae. The intent of this report is to gather facts about precisely what is happening in Arizona in connection with these feedstocks—e.g. how much WVO is there? where is it currently going? what agricultural feedstocks looks promising for our region?—in order to enable regional biofuel producers to make solid investment decisions and to help policymakers who are interested in advancing the regional production of biofuels.

Waste Vegetable Oil (WVO)

Waste vegetable oil (WVO), also known as “yellow grease,” is used as a feedstock for biodiesel production through a process of transesterification. WVO is utilized for biodiesel production because of its abundance, and is otherwise considered a nuisance to dispose of under applicable law. The most common use for WVO is not, however, in the production of biodiesel, but rather as a flavor enhancing additive in animal feed. Additional uses for WVO include additives in paints, cosmetics, lubricants, insulators in the electrical industry, and in the production of polyurethane plastics. The number of industry applications using WVO continues to grow as many manufacturers look to increase the ecological appeal of their products by using eco-friendly materials.¹

WVO Supply

Restaurants

The restaurant industry produces the greatest quantity of WVO. The National Restaurant Association (NRA) website listed 8,758 food establishments in Phoenix (our WVO analysis focuses specifically on the greater Phoenix region) in 2007,² consistent with the Arizona Restaurant and Hospitality Association estimate of 8,000 to 10,000 food service establishments currently operating in the greater Phoenix area. Restaurants are the bulk of these food service establishments, but these statistics also include school cafeterias, hotel buffets, hospital cafeterias, and convenience stores that serve hot food.

The Amereco Biofuels Corporation reports that most restaurants produce between 35 and 200 gallons of WVO per month, and that the average restaurant produces 150 gallons monthly.³ An estimate from A1 Restaurant Services places WVO production between 100 and 200 gallons per month.⁴ Others in the industry suggest that an average of 60 gallons per month is more reasonable.⁵ This lower number is consistent with the only known study of per-restaurant WVO volumes in connection with potential biodiesel production, performed by Cornell University's

¹ Available online from Wikipedia.com at http://en.wikipedia.org/wiki/Vegetable_oil.

² Available online from restaurant.com at <http://www.restaurant.org/research/state/index.cfm>.

³ Email discussions from Torrey Kolesar formerly of Desert Biofuels Initiatives, Inc.

⁴ Phone call with A1 Restaurant Services Service and Sales Manager (Patrick Neel) (602) 252-7867; see <http://a1restaurantservices.com/Services.aspx>.

⁵ E-mail discussion with Gene Leach of Dynamite Biofuels Co-op.

Cooperative Extension in New York City and focused on the Borough of Brooklyn. The Cornell study found an average of 53 gallons of WVO per month per restaurant.⁶ For the purposes of this report we will use both the more conservative 60 gallons per month figure and the higher 150 gallons per month figure to generate estimates, forming the low end and the high end of our estimates range.

Assuming there are 9,000 food service establishments in the area, estimates from the Phoenix restaurant industry suggest a total monthly WVO output of between 540,000 and 1.35 million gallons. Over the course of a year, the local restaurant industry just the Phoenix area alone produces between 6.5 million and 16.2 million gallons of WVO.

Grocery Stores and Supermarkets

Supermarket and grocery store delis also produce WVO, but in significantly smaller quantities than restaurants. Statistics on the number of grocery stores and supermarkets in the greater Phoenix area are difficult to find and vary markedly. According to the Arizona Food Marketing Alliance, Fry's, Safeway, Albertson's, and Bashas' are the largest chain grocery stores in the valley. Google maps listed 482 Fry's food stores, 467 Safeway grocery stores, 252 Albertson's, and 230 Bashas' in the Phoenix area for a total of 1431 local grocery stores and supermarkets. Additional statistics on the number of grocery stores and supermarkets in the area were compiled from various online websites to verify the initial estimate above. There were 1,186 grocery stores and supermarkets listed within 15 miles of Phoenix through www.local.com,⁷ 1,367 locations listed through www.switchboard.com⁸ and 858 stores listed on www.local.yahoo.com.⁹ Averaging these statistics provides an estimate of approximately 1,210 grocery stores and supermarkets in the Phoenix area.

Secondary research on the volume of WVO that grocery stores and supermarkets produce is not available. Due to the insufficient secondary research, primary research is compiled from one randomly selected location of each of the four major grocers in the area. Safeway reports the highest production of WVO, followed by Albertson's, Fry's and then Bashas'. The survey results indicate a production of approximately 47 gallons of WVO per month. By extrapolation, grocery stores and supermarkets in the Phoenix area are responsible for the production of approximately 56,870 gallons of WVO per month and 682,440 gallons per year.

Factories

Large scale WVO production from factories is not prevalent in the Phoenix feedstock industry. The largest producers of WVO in the area are tortilla factories. Mission Foods, La Canasta

⁶ An Assessment of Waste Vegetable Oil Supply in Brooklyn, NY and its Potential as a Biodiesel Feedstock <http://nyc.cce.cornell.edu/emerginginitiatives/Waste%20Oils%20&%20Fats%20Supply%20Final%20Report.pdf>

⁷ Available online from [local.com](http://www.local.com) at

<http://www.local.com/results.aspx?keyword=grocery+stores+and+supermarkets&location=Phoenix%2c+AZ>.

⁸ Available online from [switchboard.com](http://www.switchboard.com) at

<http://www.switchboard.com/results.htm?MEM=1&ypercobrand=1&PR=133&ST=2&VL=&QV=&KW=Grocery+Stores+and+supermarkets&LO=Phoenix%2C+AZ&SD=15&semChannelId=&semSessionId=&search.x=59&search.y=12>.

⁹ Yahoo maps available online at

http://local.yahoo.com/results?p=Grocery+Stores&ycafilt=96925834&fr=&sortby=&csz=Phoenix%2C+AZ&flnstr=&flsstr=&ppg_nm=1&pg_nm=2&xargs=&start=7.

Tortillas, and Mi Ranchito each have a single tortilla manufacturing plant in the Phoenix area. Phoenix is home to these tortilla factories, but lacks chip manufacturers that may otherwise also contribute to WVO feedstock in the Phoenix area. Reports show that La Canasta produces from 145 to 200 gallons of WVO per month.¹⁰ If La Canasta's average output of 175 gallons per month is representative of other tortilla factories, then Phoenix factories are responsible for the production of 6,300 gallons of WVO per year.

WVO Production Summary

In a single month between 600,000 and 1.4 million gallons of WVO are produced within the valley by the food service industry, grocery stores and factories combined. Over the course of an entire year, the Phoenix area produces between 7.16 and 16.89 million gallons of WVO.

WVO Collectors

Competition for larger quantity sources of WVO in the Phoenix area is keen, with a number of companies contending for a portion of the available feedstock. Baker Commodities, a commercial rendering company, is the principal collector in the Phoenix area. Rendering companies such as Baker Commodities collect and recycle WVO and other animal byproducts into useable goods. According to Baker Commodities, it is the only company in Arizona that is licensed to recycle WVO into a useable product.¹¹ Baker Commodities collects approximately one million pounds of WVO per month from restaurants. Each gallon of WVO weighs 7.5 lbs, so they collect roughly 133,333 gallons of WVO per month, and 1.6 million gallons in a year.¹² The Baker Commodities plant in Phoenix processes the collected WVO and then sells it to dairy farmers as an additive in cow feed.¹³

Arizona Biodiesel collects and processes WVO from nearly 1,000 restaurants in the area. The majority of the restaurants Arizona Biodiesel collects from are located in Phoenix, but they also work with restaurants located in Flagstaff and Tucson. Arizona Biodiesel collects approximately 60,000 gallons of WVO each month, or roughly 720,000 gallons per year,¹⁴ and processes it into biodiesel, which they recently began selling to the general public.¹⁵

A1 Restaurant Services collects approximately 53,333 gallons (400,000 lbs) of WVO per month, for a total of 640,000 gallons per year. They collect from restaurants as well as some grocery stores, schools and hospitals. A1 Restaurant Services reports that the WVO they collect is turned into biodiesel by a local company or is sold as an animal feed additive.¹⁶

Dynamite Biofuels Co-op is a locally operated cooperative that collects WVO from more than a dozen restaurants in the Phoenix area. Its members process WVO into biodiesel for their own use. The co-op uses a system that monitors collection container capacity, which alerts the co-op

¹⁰ Phone call with Baker Commodities Trap Supervisor (David Callaway) (602) 254-5971.

¹¹ *Id.*

¹² *Id.*

¹³ See Baker Commodities supra note 9.

¹⁴ Interview with President of AZ Biodiesel (Dan Rees); see <http://www.azbiodiesel.com/index.htm>.

¹⁵ *Id.*

¹⁶ Phone call with A1 Restaurant Services Service and Sales Manager (Patrick Neel) (602) 252-7867 information also available online at <http://a1restaurantservices.com/Services.aspx>.

to collect from its restaurants about every two weeks.¹⁷ Dynamite currently collects approximately 4,800 gallons per year.¹⁸

Individuals often referred to as homebrewers are also vying for a share of the WVO feedstock. It is difficult to estimate the number of homebrewers in the Phoenix area as well as the quantity of WVO they are gathering, but it is likely that just two or three restaurants would be able to supply a homebrewer with a sufficient amount of WVO to process for personal use.¹⁹

Unfortunately, not all waste vegetable oil is being used to create secondary products such as biodiesel.²⁰ Especially for small food service establishments, the cost of having WVO collected can be too expensive, and often times may be poured down the drain, or disposed of in other unlawful ways.

Improperly disposed grease can have serious and costly consequences. The City of Phoenix attributed 68% of the 88 sewer overflows in 2006 to grease and oil. In addition, in 2006 there were 80 blockages attributed to grease and oil. It is unclear how much of this grease and oil comes from commercial establishments. The City of Phoenix currently attributes the majority to residential and apartment buildings.²¹

Where is the WVO going?

Rendering and collection companies, along with Arizona Biodiesel and the Dynamite Biofuels Co-op, account for between as low as 18% to as high as 41% of the projected Phoenix WVO feedstock supply (i.e., those entities collect that percentage of the generated WVO). Home brewers collect some of the available WVO, but the destination of a large portion of the feedstock remains a mystery.

Of the WVO that is collected, the majority is evidently used for agricultural purposes. All of the WVO that is collected locally by Baker Commodities (est. 1.6M gal/year) is taken to their plant in Phoenix to be processed on site and then sold to Arizona dairy farmers. A1 Restaurant Services sells an unspecified portion of the 640,000 gal/year of WVO that it collects to be used locally in animal feed. Imperial Western Products, a California based agricultural company, also receives a portion of the WVO that A1 Restaurant Services collects.²²

The 720,000 gal/year of WVO collected by Arizona Biodiesel is converted to biodiesel that is sold locally. Some portion of the WVO collected by A1 Restaurant Services is sold to a different “local biodiesel company” – possibly Amereco Biofuels, who recently began selling WVO-

¹⁷ Email communication with Gene Leach of Dynamite Biofuels Co-op, information also available online at <http://www.dynamite.coop/index.jsp?pagename=partners.jsp&scrolling=no>.

¹⁸ E-mail discussion with Gene Leach, Dynamite Biofuels.

¹⁹ *Id.*

²⁰ “Portraits in Biodiesel”, Tucson Weekly, March 29, 2007 available online at <http://www.tucsonweekly.com/gbase/Currents/Content?oid=oid%3A94246>.

²¹ Conclusions drawn from material compiled by Ken Karnes, Chief Water Quality Inspector for the City of Phoenix Pretreatment Program and provided to DBI

²² See A1 Restaurant Services *supra* at note 15.

derived biodiesel to fleet users locally and in Las Vegas, and via a retail channel in Phoenix.²³ The roughly 4,800 gal/year of WVO that Dynamite Biofuels Co-op collects from restaurants in the area is processed locally into biodiesel for personal use.²⁴

A significant amount of WVO generated in the area is unaccounted for: between 4 million (using our conservative estimate) and 13 million (using our higher estimate) gal/year. Some modest amount is presumably being used by biodiesel homebrewers. While there are no studies that estimate the number of homebrewers in the region, judging from mailing list membership numbers²⁵ and the experience of members of the generally close-knit homebrew community, it seems safe to assume that the number of active area homebrewers is well under 1,000. Even assuming an extremely robust homebrew community of 1,000 homebrewers using 2,000 gallons of WVO each²⁶ per year (totaling 2 million gal/year), this leaves between 2 and 11 million gallons of WVO unaccounted for.

It seems reasonable to conclude that a portion of the “missing” 11 million-plus gallons of WVO is being disposed of improperly, and contributing to the costly sewer overflows and blockages that many municipalities experience.

In addition to hard costs imposed by improperly disposed WVO, there are notable opportunity costs associated with the current situation. Desert Biofuels Initiative has previously estimated that annually replacing 12.5 million gallons of petroleum diesel used in Maricopa County with WVO-derived biodiesel would result in saving over 100,000 tons of CO₂ from being released into local air per year,²⁷ as well as other significant environmental benefits (dramatically reduced particulates and other harmful emissions). These benefits are not achieved when (a) the majority of local WVO is not reused at all, and (b) the majority of local WVO that is reused is processed into animal feed.

Costs of WVO Collection

In Arizona, currently WVO producers frequently get paid by those collecting the grease, provided that the producer generates sufficient amounts of WVO to make the collection process economical for the collector. However, this has not always been the case since supply and

²³ Phoenix Business Journal, “Amereco is first Arizona company to turn used cooking oil into biodiesel on commercial basis” <http://phoenix.bizjournals.com/phoenix/stories/2008/11/03/focus1.html?b=1225688400>

²⁴ See Gene Leach supra note 16.

²⁵ As of December 10, 2008, the Tucson BIG Biodiesel Cooperative (BBC) mailing list hosted on Yahoo Groups had 126 members. The Tucson BBC list is the leading list focused on Arizona homebrewers, and includes members from Tucson, Phoenix and elsewhere throughout the state and world. Not all members are active homebrewers.

²⁶ See <http://desertbiofuels.blogspot.com/2008/08/unfortunate-opportunity.html>, note 2, for an explanation of the 2000 gal/year figure.

²⁷ See <http://desertbiofuels.blogspot.com/2008/03/wvo-swags-for-public-beta-test.html>. The analysis preceded the more detailed analysis of WVO amounts that is in this report, and went as follows: 21155 “Food Establishments” in Maricopa County times 50 gal/month equals 12,693,000 gals WVO per year in the greater Phoenix area. Using 22 lbs of CO₂ per gallon of diesel fuel, and reducing that by 78% when running B100 equals a net CO₂ reduction of 217,811,880 lbs (108,906 tons) of CO₂ removed from the Valley by converting that WVO to biodiesel and displacing the petroleum diesel that would otherwise be used here (because the 78% reduction is “life-cycle CO₂ emissions” compared to petroleum diesel, the local CO₂ reduction is probably somewhat less, but we used the 78% figure without adjustment). Sources are cited at the URL above.

demand drives market cycles. As of the late summer and early fall of 2008, Baker Commodities pays their suppliers 5¢ per pound of WVO²⁸ (about 37.5¢ per gallon), whereas A1 Restaurant services currently pays 35¢ per gallon of WVO.²⁹ A1 Restaurant Services then generates a profit by shipping some of its grease at an undisclosed price to Imperial Western Products of California. A1 Restaurant Services also reports that just two years ago, restaurants were paying 13¢ per gallon for WVO collection.³⁰

Dynamite Biofuels Co-op does not charge for WVO collection. This enticement to suppliers is attractive to restaurants in three ways. First, it makes a positive impact on the environment, which is popular with consumers today. Also, it reduces the cost of overhead by having to budget for lawful disposal of the grease. Finally, it makes compliance with applicable law easier for the restaurants. Arizona Biodiesel also advertised free WVO collection until just recently, but the company is now being forced to pay restaurants 25¢ for every gallon they collect.³¹

Agricultural Feedstock

There are two approaches for making biofuels using agricultural feedstock. One method is to produce high-sugar crops such as sugar cane to create ethanol through fermentation. Crops high in starch, such as corn, can also be used for ethanol production by converting the starch into sugars that can then be fermented.³² A second approach for making biofuels using agricultural feedstock is to produce crops high in vegetable oil, such as soybean, which can be refined and used for biodiesel. In the United States, soy is the primary feedstock for the purpose of producing biodiesel. However, as the cost of soybeans increase biodiesel producers look to cheaper alternatives.³³

Not all feedstock is an option in Arizona's arid climate, and crops such as soybeans may be less suitable for agricultural feedstock in the southwest.³⁴ Fortunately, almost any oil-rich seed, plant, or biowaste can be used for conversion to biodiesel using second-generation biofuel crops. Crop residues of all kinds can be especially useful feedstock in Arizona with an estimated 351 thousand tons per year available in Arizona.³⁵ However, over-harvesting of such feedstock is a concern for soil reconstruction since these residues provide valuable organic matter that is needed to replenish the soil.³⁶ The following table is an alphabetical list of crops and agricultural

²⁸ See Baker Commodities supra note 9.

²⁹ See A1 Restaurant Services supra at note 15.

³⁰ Information from industry representatives obtained by phone calls with A1 Restaurant Services Service and Sales Manager (see A1 Restaurant Services supra at note 15), Imperial Western (see Phone call with Imperial Western Products supra note 21), and Baker Commodities Trap Supervisor (see Baker Commodities supra note 9).

³¹ See President of AZ Biodiesel supra note 13.

³² "IEA Energy Technology Essentials", January 2007 available at <http://www.iea.org/Textbase/techno/essentials.htm>.

³³ Soybeans made up 64% dedicated biodiesel production in 2004, but only 44% 2006 in favor of movement towards multi-feedstock, such as rapeseed and palm. Biodiesel 2020: A global Market Survey available at <http://www.emerging-markets.com/biodiesel/>.

³⁴ Arizona Biodiesel Board web posting September 9, 2007 available at <http://www.inkacola.com/abb/home1/?q=node/8>.

³⁵ Milbrandt, Anelia, 2005: "A Geographic Perspective on the Current Biomass Resource Availability in the United States", National Renewable Energy Laboratory, Golden, CO.

³⁶ "Potential Impacts of Biofuel Production on Soils", Paper Series published by Alberta Canada's Department of Agriculture and Rural Development available on line at

residue used for biodiesel production in the U.S., some of which may be well suited for the Arizona climate.

Table 1. First and Second Generation Biofuels Agricultural Feedstock for Biodiesel Production in the U.S.

Feedstock	Description/Use
Alfalfa*	Grows well in Arizona and is one of the most widely grown crops in the U.S. creating a well-developed industry for alfalfa cultivar development and seed production, processing, and distribution. ³⁷
Canola/ Rapeseed	Canola ("Canadian oil, low acid") is cultivated from a group of rapeseed variants used for the manufacture of biodiesel. Rapeseed is a well-established and preferred feedstock in Europe because of the high oil yield. It is also used the United States, but may be becoming a more costly alternative than other feedstock options. ³⁸
Cereal straw and Corn stover	Non-edible crop residue from harvests such as wheat and corn that provides a hearty resource for biodiesel agricultural feedstock. Over-harvesting of such feedstock may degrade the land by removing valuable organic matter that would otherwise be left for soil reconstruction. ³⁹
Coconut	Copra is the dried meat, or kernel, of the coconut used for biodiesel production. The harvesting of this oil-rich feedstock for biodiesel, as well as competition for food, is causing shortages and price increases in some areas. ⁴⁰
Cotton*	Cottonseed can be used for biodiesel, ⁴¹ and cotton oil soapstock has been studied as a biodiesel option for a fuel blend. ⁴²
Hybrid Poplar (CRP land, abandoned mines)*	Fast growing tree that can reach 90 ft in 6 years. ⁴³ This feedstock may also have the added benefit of greater greenhouse gas emission offset than other agricultural feedstock. ⁴⁴

[http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/crop12150](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/crop12150).

³⁷ Samac, D.A., Jung, H.G., Lamb, J.F.S., Whitepaper: "The Potential Use of Alfalfa as a Feedstock for Biofuels and Bioproducts," USDA, Agricultural Research Service, St. Paul, MN, Plant Science Research Unit available on line at <http://bio.uwex.edu/library/documents/AlfalfaBiofuelBioproductWhitepaper.pdf>.

³⁸ Van Dyne, D., Raymer, P., Biodiesel Production Potential from Industrial Rapeseed in the Southeastern United States a Report Prepared for The Southeastern Biomass Energy Program, October 31,1992.

³⁹ See Milbrandt supra note 31.

⁴⁰ Biodiesel and Ethanol Investing report dated April 9, 2008 available on line at <http://www.biodieselinvesting.com/biodiesel-archives/2008/04/09/coconut-biodiesel-demand-to-cause-copra-shortage/>.

⁴¹ "Can cottonseed join biodiesel race?" Southeast Farm Press, August 29, 2007 available at <http://southeastfarmpress.com/cotton/082907-cottonseed-biofuel/>.

⁴² Keskin, A., Guru, M., Altiparmak, D., Aydin, K., "Using of Cotton Oil Soapstock Biodiesel-Diesel Fuel Blends as an Alternative Diesel Fuel", Renewable Energy, 2008, vol. 33, no 4, pp. 553-557 available on line at <http://cat.inist.fr/?aModele=afficheN&cpsidt=20053540>.

⁴³ Article from Purdue News dated August 23, 2006 available online at <http://www.purdue.edu/UNS/html4ever/2006/060823.Chapple.poplar.html>.

Jatropha (low water use plant)*	Hearty, drought resistant plant native to Central America but also grows well in many climates. Goldman Sachs recently cited Jatropha as one of the best candidates for future biodiesel production. ⁴⁵
Jojoba (pronounced ho-HO-baa)*	Seeds from this shrub native to the Sonoran and Mojave deserts of Arizona, California, and Mexico show promise for biodiesel production because it thrives in Arizona's climate. ⁴⁶
Lesquerella*	Hearty plant from the mustard family that can grow in poor soil conditions and crevices of rocks. Seeds are used to produce the oil for biodiesel production in Arizona, Texas, and Illinois. ⁴⁷
Mustard seed	Widely used in Europe and Australia, and has received some attention in the southern U.S. ⁴⁸
Moringa*	A tree that is a multipurpose feedstock providing food and materials for biodiesel production that is gaining popularity over the use of Jatropha. ^{49 50}
Palm oil	Similar to coconut, not only is the fruit the source of the oil, it is also high in saturated fats. This feedstock is criticized by some groups for not being a good source of biodiesel because of the clearing of forests for palm plantations offsets the savings in greenhouse gas reduction that would otherwise be a benefit from biofuels. ⁵¹
Peanut	Peanut oil has a long history of an alternative fuel source dating back to a least World War II in the U.S., but may be cost prohibitive compared to other option for agricultural feedstock. ⁵²
Soybeans	Most common source of biodiesel (along with WVO), but is increasing in cost and may not be a good crop for the Arizona climate. ⁵³ In 2004 soybeans were 64% of the dedicated biodiesel production, but in 2006 it was only 44% in favor of movement towards multi-feedstock such as

⁴⁴ Paul R. Adler, Stephen J. Del Grosso, William J. Parton (2007) Life-Cycle Assessment of Net Greenhouse-Gas Flux for Bioenergy Cropping Systems, Ecological Applications: Vol. 17, No. 3, pp. 675-691.

⁴⁵ Barta, P., Jatropha Plant Gains Steam In Global Race for Biofuels, The Wall Street Journal, August 24, 2007 available online at http://online.wsj.com/article/SB118788662080906716.html?mod=googlenews_wsj.

⁴⁶ "Jojoba Fuel", article by Christine Lepisto posted on Treehugger.com on March 27, 2005 available online at http://www.treehugger.com/files/2005/03/jojoba_fuel_1.php.

⁴⁷ "Lesquerella: The next source of biofuel?", article posted on Westernfarmpress.com on August 4, 2008 available online at <http://westernfarmpress.com/news/biofuels-lesquerella-0804/>.

⁴⁸ "Biodiesel demand creates opportunities for South's farms", article posted on Westernfarmpress.com on March 2, 2007 available online at http://deltafarmpress.com/mag/farming_biodiesel_demand_creates/.

⁴⁹ "Multidimensional Moringa" article by Susanne Retka Schill posted by Biodiesel Magazine in June 2008 issue available online at http://www.biodieselmagazine.com/article.jsp?article_id=2380.

⁵⁰ "Feedstock Development and Sustainability", article by Susanne Retka Schill posted by Biodiesel Magazine in April 2008 issue available online at http://www.biodieselmagazine.com/article.jsp?article_id=2210&q=&page=2.

⁵¹ "Palm oil, forests and climate change" from Greenpeace website available at <http://www.greenpeace.org.uk/forests/faq-palm-oil-forests-and-climate-change>.

⁵² "Peanut Biodiesel Promising but Costly Alternative Fuel", Southwest Farm Press, November 1, 2006 available at <http://southwestfarmpress.com/news/110106-peanut-biodiesel/>.

⁵³ "Biodiesel Performance, Costs, and Use", article by Anthony Radich available online at <http://www.eia.doe.gov/oiaf/analysispaper/biodiesel/>.

⁵⁴ See UN Biofuels Report supra note 1.

	rapeseed and palm. ⁵⁴
Sunflowers	Sunflowers are easy to cultivate, grow well in Arizona, and have been a good feedstock for biodiesel. ⁵⁵ Soil quality may be a concern for large production of this type of feedstock, as would be water consumption.
Switchgrass (CRP land, abandoned mines)*	Switchgrass is native to North America and fast growing possibly making it a good option for Arizona. The U.S. Department of Energy is doing significant research at Oak Ridge National Laboratory on this plant, and there are also efforts underway in Arizona. ^{56 57} Collection of switchgrass is generally less expensive than collection of straw or corn stover further giving it potential for large-scale cultivation for biodiesel. ⁵⁸
Wheat straw	Another source of biofuel that can be grown on suitable agricultural land, but probably not a good choice in Arizona. Critics say that this feedstock uses land that could otherwise be used for food production, and also that it inflates grain prices contributing to food shortages in parts of the world. ⁵⁹
Willow (CRP land, abandoned mines)*	Development of this feedstock is taking place in Europe and New Zealand. ⁶⁰ May be promising for Arizona because it produces more biomass than many other feedstocks and can be grown on marginal land, but no known research and development currently taking place in Arizona.

*Feedstock that may be best suited for Arizona climate.

Most Promising Agricultural Feedstock in Arizona

Alfalfa, Cotton, Jatropha, Jojoba, Lesquerella, and Moringa are most promising agricultural feedstocks in Arizona considering the following variables: heartiness of the crop, water use, high biomass yield, fast growth, ability to grow in poor soil conditions, and ease of cultivation. Further, as is the case with alfalfa and cotton, already having in place a well-developed industry for production, processing, and distribution is also favorable. There are also a number of crops grown on Conservation Reserve Program (CRP) lands and abandoned open pit mines that show

⁵⁵ “Biodiesel blooms: Cotton County man creates diesel fuel from Cotton” article by David Page in Business Services Industry dated Aug 14, 2006 available online at http://findarticles.com/p/articles/mi_qn4182/is_20060814/ai_n16647115

⁵⁶ U.S. Department of Energy: Energy Efficiency and Renewable Energy Biomass Program website at http://www1.eere.energy.gov/biomass/biomass_basics_faqs.html.

⁵⁷ “Biofuels from Switchgrass: Greener Energy Pastures”, pamphlet produced for Department of Energy’s Office of Transportation Technologies and the Office of Power Technologies within the Office of Energy Efficiency and Renewable Energy available online at <http://bioenergy.ornl.gov/papers/misc/switgrs.html>.

⁵⁸ Kuma, Amit, Switchgrass (*Panicum virgatum*, L.) Delivery to a Biorefinery Using Integrated Biomass Supply Analysis and Logistics (IBSAL) Model, Bioresource Technology Volume 98, Issue 5, March 2007, Pages 1033-1044 available online at <http://www.sciencedirect.com/science/journal/09608524>.

⁵⁹ “Ethanol and bio-diesel: Fuels or threats to food security?” by Abdul Waheed Bhutto published in Online Journal April 14, 2008 available online at http://onlinejournal.com/artman/publish/article_3168.shtml.

⁶⁰ “Kiwi Company Pushes Salix as Biofuel Crop” by Giles Clark in Biofuel Review dated July 9, 2008 available online at <http://www.biofuelreview.com/content/view/1644/1/>.

potential for biodiesel feedstock in Arizona. Some of these crops are switchgrass, willow, and hybrid poplar.

Conservation Reserve Program (CRP) Lands and Abandoned Mines

Expanding available land for feedstock production in Arizona can be done using areas that would otherwise be unsuitable for conventional agricultural. CRP land and abandoned mines are two such options for agricultural feedstock production. The CRP program is available to agricultural landowners and is administered by the USDA Farm Service Agency. The program offers technical and financial assistance to farmers to address natural resource concerns on their lands by promoting the use of a number of dedicated energy crops such as switchgrass, willow, and hybrid poplar. These crops may serve a dual purpose as a viable source of feedstock for biodiesel production while also providing erosion protection to agricultural areas subject to soil degradation.⁶¹

Another feedstock option for producing crops on land that would otherwise be unsuitable for conventional crop growth is the use of abandoned mines. Abandoned mines are ideal for energy crops since this property would otherwise be unusable, often remaining blight on the community. Mining companies often leave behind a community where the only source of revenue was mining. These communities are left destitute since most jobs were either working for the mines themselves, or in some way supportive of the mining industry. Arizona has an abundance of land once productive for mining but now left vacant, or even hazardous. The communities of Globe and Bisbee are just two notable examples of these types of communities in Arizona where once thriving mining communities now struggle economically and also have large sections of mining land that is no longer suitable for any purpose. Energy crops could thrive on such property and also help reconstruct and beautify the wasteland. Moreover, large-scale biodiesel production in such communities can help create much-needed jobs and resurrect these economically depressed communities.

Arizona Feedstock Research

Feedstock research generally focuses on one, or a combination, of the following areas:

- *Production*: resource assessment, sustainability/agronomics, plant science/agronomics;
- *Harvesting and Collection*: selective harvest for sustainability, single pass harvesting and collection, bulk harvesting and collection;
- *Storage*: feedstock quality and monitoring, dry storage systems, wet storage systems;
- *Preprocessing*: biomass material properties, biomass physical state alteration, biomass bulk material handling;
- *System Integration*: subsystem specifications, overall integration, market policy; and
- *Transportation*: integrated systems for the utilization of existing infrastructure.⁶²

Agricultural feedstock research for biodiesel in Arizona is taking place in the following areas:

⁶¹ Milbrandt, Anelia, "A Geographic Perspective on the Current Biomass Resource Availability in the United States", National Renewable Energy Laboratory, Golden, CO, 2005.

⁶² See UN Biofuels Report supra note 1.

Jatropha

Arizona Bio Fuels Research is looking into Jatropha. This is a Phoenix-based research and development company receiving most of its funding through private sources. Some of their environment-focused projects include cellulosic ethanol production from plant waste, solar powered hot water reactor systems, and the development of a Jatropha agricultural production industry in the southwest.⁶³⁶⁴ Contact information:

Dave Mason, Ph.D.
Arizona Bio Fuels Research
AZBioFuels@phoenixcomputerlabs.com

At least two other entities in Arizona are engaged in Jatropha-related projects, but have not yet publicly released details of their efforts. More information will be posted at the Desert Biofuels Initiative website when available.

Lesquerella

With funding from USDA's Cooperative State Research, Education, and Extension Service (CSREES) research on Lesquerella for biodiesel feedstock is ongoing at USDA's Arid Land Agriculture Research Center in Maricopa.⁶⁵ Contact information:

Albert Clemmens
Center Director
bert.clemmens@ars.usda.gov
(520) 316-6373
21881 North Cardon Lane
Maricopa AZ 85239

Sorghum (for ethanol)

Researchers at the University of Arizona (UA) are using the grass Sorghum for ethanol production.⁶⁶ Biodiesel is not yet the focus, but this may change. Moreover, contacts with this research group may prove to be helpful considering the algae work taking place at UA with an affiliate researcher, discussed below. Contact information:

Don Slack, Ph.D.
Department Head
Agricultural and Biosystems Engineering
University of Arizona
slackd@email.arizona.edu

⁶³ Arizona Bio Fuels website at <http://www.phoenixcomputerlabs.com/AZBioFuels/jatropha1.html>.

⁶⁴ AAA BioFuel website at http://www.aabiofuel.com/BioFuel%20Development/Biodiesel_Project_Proposal_Financial.htm

⁶⁵ "Lesquerella: The Next Source of Biofuel" by Stacy Kish dated July 31, 2008 on USDA's Cooperative State Research, Education, and Extension Service (CSREES) website at http://www.csrees.usda.gov/newsroom/impact/2008/nri/07311_lesquerella.html.

⁶⁶ "Wanted: A Viable Biofuel Crop to Grow in Semi-arid Arizona" by Joe Gelt published on the Arizona Small Utilities Association website at http://www.asua.org/semi_arid_arizona.htm and https://www3893.sslldomain.com/asua/semi_arid_arizona.htm.

(520) 621-7230

Algae

Algae are a third generation biofuel producing as much as 30-times more energy per acre than many agricultural biodiesel feedstocks.⁶⁷ Algal culture for biodiesel production is catching the attention of the biodiesel community, especially in Arizona. Algae are becoming popular because of exceptionally high yield, and also because it is extremely easy to grow in even the most inhospitable environments.⁶⁸ Further, algae cultivation in industrial areas, such as near power plants or smokestacks, can help clean the air using the photosynthetic process.⁶⁹

Research on algae biofuel production has been underway in the U.S. for many years. The Department of Energy funded the National Renewable Energy Laboratory, known as the Aquatic Species Program, from 1978 through 1996. The focus of this program was research on high oil yield algae for large-scale biodiesel production, and on identifying those varieties of algae best suited for biodiesel production.⁷⁰ Government and privately funded research into algae biodiesel production continue today throughout the U.S., including in Arizona.⁷¹

One Arizona group dedicated to algae biodiesel research and development is **Algae BioFuels**, a subsidiary of **PetroSun**. In January 2008, Algae BioFuels entered into a joint venture to construct and operate an algae biodiesel plant near Coolidge, Arizona.⁷² PetroSun plans to own and operate the algae farms supporting this biodiesel plant, with estimates of 30 million gallons of algae biodiesel production capacity per year, with the residual biomass processed into ethanol. PetroSun says that this biodiesel plant will generate all of its own electricity, use non-potable water or saltwater for its production needs, consume no fossil fuels, and will be carbon neutral. Construction was anticipated to start the third quarter of 2008,⁷³ but evidently has not started as of December 2008. Contact information:

PetroSun Inc.
Corporate Headquarters
6900 East Camelback Road, Suite 525

⁶⁷"A Promising Oil Alternative: Algae Energy" by Eviana Hartman published in the Washington Post January 6, 2008 available online at <http://www.washingtonpost.com/wp-dyn/content/article/2008/01/03/AR2008010303907.html>.

⁶⁸ "Propagation of Algae by Use of Covered Ponds" by James E. Miller available at Algal Oil and Biodiesel Production website last updated on Aug 23 2008 available at <http://algaloidiesel.wetpaint.com/page/PROPAGATION+OF+ALGAE+BY+USE+OF+COVERED+PONDS?t=anon>.

⁶⁹ Information available on line at <http://www.oilgae.com/>.

⁷⁰ Article available online at <http://www.green-trust.org/biodiesel.htm>

⁷¹ "LiveFuels Alliance Launches; National US Program to Advance Algae Biodiesel Research," Biofuels Digest, October 22, 2007 available online at <http://www.biofuelsdigest.com/blog2/2007/10/22/livefuels-alliance-launches-national-us-program-to-advance-algae-biodiesel-research/>.

⁷² "PetroSun Announces Formation of Algae BioFuels; Subsidiary to Develop Algae-Based Biodiesel; Alternative Energy Resource to Supplement Petroleum-Based Fuels", June 22, 2006, available online from BusinessWire.com at http://www.businesswire.com/portal/site/google/?ndmViewId=news_view&newsId=20060622005586&newsLang=en.

⁷³ "PetroSun BioFuels Refining Executes Joint Venture Agreement to Locate a Biodiesel Refinery in Coolidge, Arizona", January 9, 2008 available online from Yahoo! Finance at <http://biz.yahoo.com/iw/080109/0346418.html>.

Scottsdale, Arizona 85251
(480) 425-4290
petrosun@cox.net

Another algae based biodiesel project in Arizona took place with **Arizona Public Service (APS)**, in partnership with **GreenFuel Technologies Corporation (GFT)**, headquartered in Cambridge, Massachusetts. APS is an energy company providing power throughout the state and its work focuses on developing a process for growing algae using emissions from fossil fuel combustion to produce biodiesel.^{74 75} APS is also involved in cyanobacteria biodiesel, discussed below. Contact information for APS and GFT:

Arizona Public Service (APS)
400 N 5th St
Phoenix, AZ 85004-3902
(602) 250-1000
www.aps.com

GreenFuel Technologies
29 Smith Place
Cambridge, MA 02138
(617) 234-0077
<http://www.greenfuelonline.com/>

XL Renewables is a Phoenix-based company that has developed a cost-effective agriculturally-based solution to algae production and harvesting called the XL Super Trough System. XL Renewables goal is to enable its customers to source large algae production volumes at low cost with low risk.

Contact information:

XL Renewables
Phoenix, AZ
<http://xlrenewables.com/>

Diversified Energy is a Gilbert, AZ-based company that, among other things, has developed an algae production and harvesting model they call “Simgae” (for “simplified algae”).

Contact information:

⁷⁴ “Arizona Public Service and GreenFuel Technologies Corp. Successfully Recycle Power Plant Flue Gases into Transportation-Grade Biodiesel and Ethanol”, December 1, 2006 available online WorldPress.com at <http://phoenixarizona.wordpress.com/2006/12/01/arizona-public-service-and-greenfuel-technologies-corp-successfully-recycle-power-plant-flue-gases-into-transportation-grade-biodiesel-and-ethanol/>.

⁷⁵ “Algae Tested as Fuel for Arizona Power Plant,” October 26, 2006, from the Associated Press available from MSNBC online at <http://www.msnbc.msn.com/id/15287313/>.

Diversified Energy Corporation
PO Box 1239
Gilbert, AZ 85299-1239
<http://www.diversified-energy.com/>

Energy Derived is a Queen Creek, AZ-based firm that has developed a unique algae harvesting and processing technology.

Contact information:

Energy Derived LLC
P.O. Box 1130
Queen Creek, AZ 85242
<http://www.energyderived.com/>

Desert Sweet Biofuels is a Gila Bend, AZ-based company that recently launched its efforts to cultivate algae for biofuels, leveraging their experience with shrimp aquaculture.

Contact information:

45075 S. Old US 80
P.O. Box A1
Gila Bend, Arizona 85337
<http://www.desertsweetbiofuels.com/>

Arizona universities are also involved with algae biodiesel development. LiveFuels Alliance, a California company, has teamed up with Sandia National Laboratories to sponsor nationwide research into commercial biodiesel production from algae.⁷⁶ Some of this work is being done with UOP, a subsidiary of Honeywell, and researchers at **Arizona State University** (ASU) to advance technology that converts algae to jet fuel.⁷⁷ The ASU scientists involved with developing the technology are growing algae in solar tubes at ASU's polytechnic campus to demonstrate feasibility of large-scale cultivation. **ASU's Laboratory for Algae Research & Biotechnology** is principally involved with these efforts, and has recently secured \$3 million in private and public funding to continue work on the project.⁷⁸ Contacts for the ASU researchers, LiveFuels Alliance in California, and UOP headquartered in Illinois:

Qiang Hu, Ph.D.
Arizona State University
Department of Applied Biosciences
(480)727-1387

⁷⁶ "LiveFuels Alliance Launches; National US Program to Advance Algae Biodiesel Research", October 22, 2007, <http://www.biofuelsdigest.com/blog2/2007/10/22/livefuels-alliance-launches-national-us-program-to-advance-algae-biodiesel-research/>

⁷⁷ "Honeywell's UOP Developing Bio-Jet Fuel For Military", July 6, 2007, available online from Environmental Leader at <http://www.environmentalleader.com/2007/07/06/honeywells-uop-developing-bio-jet-fuel-for-military/>.

⁷⁸ "Algae-to-fuel work gets \$3", The Arizona Republic, September 2, 2008 article available online at <http://www.azcentral.com/arizonarepublic/business/articles/2008/09/02/20080902biz-jetfuel0902.html>.

huqiang@asu.edu

Milton Sommerfeld, Ph.D.
Arizona State University
Department of Applied Biosciences
(480)727-1050
Milton.Sommerfeld@asu.edu

LiveFuels Inc.
1300 Industrial Road
San Carlos, CA 94070
(650) 592-0500
<http://www.livefuels.com/>

UOP Corporate Offices
25 East Algonquin Road
P.O. Box 5017
Des Plaines, IL
60017-5017
(800) 877-6184

ASU is also the home of Professor Mark R. Edwards of the Morrison School of Management and Agribusiness, who authored the book *Green Algae Strategy* and is a leading algae analyst. Professor Edwards makes a compelling case that algae can enable community-based efforts in developed and developing countries to create fuel for vehicles and cooking fires, and food for animals and people.

Mark Edwards, Ph.D.
Morrison School of Management and Agribusiness
Arizona State University
7171 E. Sonoran Arroyo Mall, MC 0180
Mesa, AZ 85212
(480) 727-1585
MARK.EDWARDS@asu.edu

There are also research interests in algae biodiesel at the **University of Arizona** (UA).⁷⁹ These efforts emphasize bench science, but have a focus on practical application as well.⁸⁰ Contact information:

Joel Cuello. Ph.D.
University of Arizona.

⁷⁹ “Wanted: A Viable Biofuel Crop to Grow in Semi-arid Arizona” by Joe Gelt published on the Arizona Small Utilities Association website at http://www.asua.org/semi_arid_arizona.htm and https://www3893.sslldomain.com/asua/semi_arid_arizona.htm.

⁸⁰ “Green’ Fuel May be Just That: Slimy Green”, article appeared in the Tucson Citizen on August 4, 2008 available online at <http://www.tucsoncitizen.com/ss/local/92674.php>.

Agricultural & Biosystems Engineering, Arid Lands Studies, and BIO5 Institute
(520) 621-7757
cuelloj@email.arizona.edu

Cyanobacteria

Another biodiesel feedstock is cyanobacteria. Commonly called blue-green algae, cyanobacteria are often considered part of a group of algae for biodiesel production. However, cyanobacteria are actually photosynthesizing bacteria with an algae-like appearance having no taxonomic relation to algae. Cyanobacteria get their name from the bluish pigment phycocyanin, which is used to capture light for photosynthesis. The bacteria also contain chlorophyll-a, the same photosynthetic pigment found in the chloroplasts of plants. Not all "blue-green" bacteria are blue; some common forms are red or pink, resulting from the pigment phycoerythrin.⁸¹ These bacteria show promise for biodiesel feedstock and are being studied in Arizona for biofuel potential.

In 2007, researchers at the **Biodesign Institute at ASU** teamed up with British Petroleum (BP) to study these photosynthetic bacteria.⁸² The ASU researchers are demonstrating the feasibility of cyanobacteria photobioreactors by implementing functional rooftop bioreactors under "real-world conditions." They are using these initial efforts to improve bacteria strains and equipment before implementing large-scale field tests.⁸³ The photobioreactor will be located at an APS power plant, discussed previously with their involvement in algae-based biodiesel. Contact information:

Wim Vermaas, D.Sc.
Arizona State University
School of Life Sciences and
Center for the Study of Early Events in Photosynthesis
(480) 965-6250
Wim@asu.edu

Thomas Moore, Ph.D.
Arizona State University
Department of Chemistry and Biochemistry
(480) 965-3308
Tom.Moore@asu.edu

⁸¹ Source: US National Oceanic and Atmospheric Administration (NOAA) glossary of terms available on line at http://www8.nos.noaa.gov/coris_glossary/index.aspx?letter=c.

⁸² "BP joins Arizona Biofuel Research Initiative" article posted on Cleantech.com November 2, 2007 available online at <http://www.cleantech.com/news/2026/bp-joins-arizona-biofuel-research-initiative>

⁸³ "Cyanobacterial Biodiesel: Tubes in the Desert" available on Arizona State University online at <http://biofuels.asu.edu/tubes.shtml>.

About the authors

About the Desert Biofuels Initiative:

Desert Biofuels Initiative, Inc. is a Phoenix, Arizona-based non-profit social venture aimed at advancing the development of a robust sustainable biofuels infrastructure in the Sonoran Desert region, throughout the U.S., and around the globe. One component of our efforts is research and policy analysis, embodied in white papers such as this one. More information at desertbiofuels.org. The Desert Biofuels Initiative engaged the ASU Technology Ventures Services Group to create this report.

About the ASU Technology Ventures Services Group:

The Arizona Technology Ventures Services Group (TVSG) was launched in 2008 as a new and enhanced effort by ASU from its predecessor, the Technology Ventures Clinic at the Sandra Day O'Connor College of Law. The TVSG directs the energy of ASU's entrepreneurial student body toward a goal of diversifying Arizona's economy through the incubation of technology companies. The authors of this report were TVSG participants.

About the Authors:

Sarah Howe

B.S. in Chemical Engineering to be awarded 2010
Barrett Honors College, Arizona State University.

Sarah has biodiesel home brewing experience and professional interests in environmental engineering. Ms. Howe can be contacted at skhowe@asu.edu.

Pete Arambula

Juris Doctor to be awarded December 2008
Sandra Day O'Connor College of Law, Arizona State University.
M.A. Physiological/Experimental Psychology, 1999
San Francisco State University

Professional interests in biotechnology, health science, civil liberty and sustainability. Mr. Arambula can be contacted at PeteArambula@msn.com.

Carrie Thompson Jones

Juris Doctor to be awarded May 2009
Sandra Day O'Connor College of Law, Arizona State University.

Ms. Thompson Jones is a former entrepreneur and business owner with professional interests in biofuels and sustainability. Ms. Thompson Jones can be contacted at carrie.xiaorei@gmail.com.