DRAFT

Biofuels in Hawai‘i: A Case Study of Hāmākua

Report by the
Department of Urban Regional Planning
Master's Practicum
Spring 2009

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The Practicum is the capstone course in fulfillment of a Masters in Urban and Regional Planning at the University of Hawai‘i at Mānoa. It offers an opportunity for students to work with a client on a pertinent and timely regional planning issue. This Spring 2009 course, entitled “Biofuels in Hawaii: The intersection between land-use planning, agricultural policy, and Hawaii’s energy future,” was sponsored by The Kohala Center.

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Executive Summary

Escalation and volatility in crude oil prices have brought energy to the forefront of policymaking in Hawaiʻi. Increasing global awareness of climate change and efforts to preserve open space in Hawaiʻi influence state residents' energy concerns. One response by State policy-makers, businesses, and local communities to these concerns is the exploration of biofuels as a possible solution. The State is drafting a Bioenergy Master Plan to develop a biofuels industry for Hawaiʻi. Numerous businesses have come forward with biofuel proposals to answer the State's call to transition to a renewable energy economy. While the State has met with these companies to explore how this transition may occur, local communities have expressed frustration with the State for not waiting until the completion of the Bioenergy Master Plan and for being excluded from the process.

This report, *Biofuels in Hāmākua: A Case Study of Hawaiʻi*, investigates the motivations for and perceptions of a biofuels industry, as well as its potential community impacts in Hawaiʻi Island. The report offers a set of recommendations based on contextualizing international, national, and State issues regarding energy, land use, production technology, policies, and biofuel crops, to a case study of the Hāmākua region in Hawaiʻi Island. The research, sponsored by the Kohala Center, has been conducted through the Department of Urban and Regional Planning at the University of Hawaiʻi at Mānoa.

The study team utilized an interdisciplinary approach, combining expertise in urban and regional planning, community development, and natural resource management. Methodology for the study involved three steps. First, the team conducted a review of existing literature on the relevant issues. Second, the study team interviewed 54 people organized into the following categories: 1) experts in energy, forestry, agriculture, and environmental management; 2) business leaders in forestry and energy; 3) proprietors of diversified agriculture, cattle ranching, and dairy farming operations; and 4) public and private sector professionals in the areas of energy, water, and community planning. Finally, the study team conducted a site visit of the Hāmākua region to gain first hand experience of the issues and meet with local stakeholders in the community, business, and government.

The case study approach was selected for its ability to gather perspectives and generate recommendations for community, County, and State decision-makers in approaching the introduction of a biofuels industry into local communities in Hawaiʻi. Hāmākua is of particular interest to biofuel businesses because of its topography, rich soil, abundant rainfall, land availability, and agricultural heritage. The region is currently at a crossroads in the shaping of its social fabric, economic engine, environmental landscape, and energy future. The geographic scope focuses on the Hāmākua region, which this report defines as extending from the rim of Waipiʻo Valley to the banks of the Wailuku River, from sea level to the summit of Mauna Kea and extending into the saddle region between Mauna Kea and Mauna Loa. The scope also includes local communities, Hawaiʻi County government, and businesses with direct interests or biofuel business proposals in the Hāmākua region. The report does not address the economic feasibility of proposed businesses or specific economic development impacts.

The following are key findings and recommendations regarding the potential impacts of a biofuel

industry in Hāmākua.

- There are considerable barriers to agriculture – food, fuel or otherwise. While the full barriers to production were outside the scope of this study, interviews with more than 50 respondents suggested that the debate about whether a biofuel industry will compete with food production lies in 1) the scale of the industry and 2) the location of biomass crops. It is undesirable, and also seemingly unlikely, for biofuel crops to be grown on prime agricultural lands. More upland areas, particularly those that have already been degraded by large-scale agriculture such as former sugar cane lands, may be a good complement to limit competition with niche crops.

- Biofuels offers potential high-skilled jobs located in Hāmākua that are consistent with the agricultural character of the region. Since the close of the sugar plantations, employment options have been limited. Biofuel companies offer jobs incorporating a variety of skill sets, including forestry, conversion, and distribution. This report estimates a biofuels industry at the current scale of existing Eucalyptus trees in Hāmākua could employ from 55 to 79 individuals.

- Benefits and impacts of a biofuel industry may not uniformly affect the entire community. While a biofuels industry may be ideal for some residents, the arrival of biofuels may be inconvenient for others. New homes and communities have developed since the close of the sugar plantations and newer residents may not be accustomed to operations of a plantation-scale agricultural industry.

- Best management practices (BMPs) influence the degree of environmental impacts. Best practices should be used to mitigate negative impacts such as soil erosion. However, many BMPs are situation specific, thus requiring research of the site and crop. Existing eucalyptus trees have been well researched and current proposals attempt to incorporate many BMPs. Nonetheless, most species of Eucalyptus trees have been found to be highly invasive and thus any proposal to expand the acreage of trees should also provide a long-term management plan.

- The Community Development Plan (CDP) should be a basis for vetting existing projects and future development proposals. The community desires participation in the planning process. The CDP provides Hāmākua an ideal vehicle for such by allowing the community to collectively address issues in order to build a more cohesive vision out of the conflicting value statements expressed in public meetings and study interviews. Businesses may then rely on the CDP in developing proposals.

The study acknowledges the many unknowns about biofuels, and therefore the uncertainty of the risks and impacts associated with producing biofuels in the Hāmākua region.

Introduction

Escalation and volatility in world crude oil prices have brought energy to the forefront of policymaking in Hawaiʻi. Increasing awareness of climate change and efforts to preserve open space in Hawaiʻi intersect closely with state energy concerns. In response, State policy-makers, businesses, and local communities have begun to explore biofuels as a possible solution. Biofuels have been a particularly contentious yet appealing solution to meet Hawaiʻi's energy needs. They are an alternative means of storing energy and can be easily adapted into our current energy infrastructure. They have the potential to reduce Hawaiʻi's reliance on imported fossil fuels, while helping to stimulate local economies. On the other hand, a local biofuel industry may compete with food producers for land and negatively affect other natural resources.

Interested biofuel producers and State government officials initiated discussions in November 2008 to explore the possibility of leasing government lands for biofuel production in the Hāmākua region of Hawaiʻi Island. This caused considerable outcry from the community, as some residents felt that making decisions on land use for bioenergy production prior to the completion of the Bioenergy Master Plan was short-sighted. In response to this concern, the Kohala Center sponsored this report to examine the potential impacts biofuel production could have in Hāmākua. This study offers recommendations relating to the potential suitability and community impacts of biofuel production in Hāmākua within the context of its history and existing community planning efforts, as well as within the context of broader energy production and consumption, local agriculture, and relevant government policies.

This paper is divided into four parts. Part I provides a framework and background for understanding Hawaiʻi's current energy situation, and potential role of biofuels, from crop to fuel. Section 1 includes an overview of energy, scaling from a global to local perspective, to illustrate Hawaiʻi's in comparison to the global energy market, as well as an overview of local agriculture. Section 2 describes biofuel feedstocks and conversion processes, while Section 3 describes policies from the global to the State-level that support biofuel production.

Part II discusses the primary motivations for and concerns regarding biofuel production in other regions of the world and how such concerns may translate to Hawaiʻi. Section 4 explores motivations for biofuels, specifically describing expected benefits with regard to energy supply and co-production, reduction in greenhouse gas emissions, and the promotion of rural economic development. In contrast, Section 5 explores the concerns that an agriculture-based biofuel industry may conflict with food production, incur negative environmental effects, and cause undesirable community impacts.

Part III connects these global issues to a Hawaiʻi-specific case study of the Hāmākua region. Section 6 defines the Hāmākua region, spatially and demographically, provides a historical overview, focusing on its agricultural past, describes existing land uses, and provides a context for business, government and community responses regarding biofuel production in the region. Insight is provided into the community through a review of Hāmākua community plans and previously proposed projects. Section 7 more specifically addresses the eucalyptus plantations that stand at the center of the controversy and also the potential relationship between forestry and ranching. Section 8 presents emergent themes from a series of more than 50 interviews conducted among experts and stakeholders related to biofuels and the Hāmākua region including: 1) scholars in the fields of bioenergy, agriculture, and forestry; 2) businesses representing potential biofuel producers, food agriculturalists, dairy farmers, and cattle ranchers; 3) local policy-makers; and 4) community members and community planning leaders.

Part IV focuses on conclusions and recommendations, based on the research presented in Parts I, II, and III. Conclusions are offered with the intention of providing a perspective and guidance to the Hāmākua community as it determines the best use of the existing trees, suitable environmental management practices, and regional planning efforts to guide the decision-making process on energy, agricultural production, and its future.

PART I: The Intersection of Energy, Land Use, Production Technology, and Policy

1. Energy and Land Use Overview

Today, most of the world's population draws its energy for transportation and electricity from fossil fuel sources. Fluctuations in oil prices have brought attention to the potential for expanding renewable energy sources, including bioenergy sources. This section describes global, national and local energy consumption and land use to provide a framework for discussions in subsequent sections about the implications of biofuel production and use and related policies.

The first three portions of Section 1 outline energy consumption and production globally, in the US, and in Hawai'i. The overview of energy use and production in Hawai'i takes particular note of how energy is consumed in the transportation and electricity sectors, and describes how biofuels may play a role in the local energy portfolio. The last portion of this section outlines the distribution of agricultural land in Hawai'i and on Hawai'i Island, including current crops, forestry, and the shift in the agricultural industry since the close of local sugar plantations.

Bioenergy Definitions. While this section discusses the consumption and production of the world's major sources of energy, it will focus on bioenergy. Bioenergy is any form of energy derived from biological sources. Biofuels are any fuel derived from biological sources, including biomass. Biomass is organic material derived from recently living organisms – its energy is derived from solar energy through photosynthesis or digestion of plant or animal material. Examples of biomass include wood, manure, leaves and stems, fibers, and oil - all of which can be processed for energy. Biofuels can be directed towards transportation or electricity generation. Biomass can be burned directly for electricity. Although liquid biofuels are often targeted towards the transportation sector, they can also be burned in electricity generators (Faaij, 2006).

Energy Types. Three main categories of primary energy used in energy generation are fossil fuels, nuclear, and renewable. Fossil fuels, the most commonly used energy source, include petroleum, coal, and natural gas products. Nuclear energy started in the 1950s and is a growing source of energy production, though it is not utilized in Hawai'i and is prohibited by amendments made to Hawai'i's constitution at the Hawai'i Constitutional Convention in 1978 (World Nuclear Association, 2009). Renewable energy refers to resources that can be replaced naturally within a short timeframe such as biomass, geothermal, hydroelectric, solar, and wind. Although the world's transportation sectors mainly rely on liquid fuels that can be drawn from fossil fuel or biofuel sources, electricity sources can be separated into two main categories – firm and intermittent power. Firm power is characterized by consistent availability and load. Firm electricity sources for Hawai'i include residual fuel oil, coal, geothermal, and municipal solid waste. Intermittent power, on the other hand, is often inconsistent or not available on demand. Local intermittent electricity sources include wind, hydroelectric, and solar photovoltaic.

1.1 Energy Consumption and Production Overview – Global, National, and Local Perspectives

1.1.1 Global Energy Consumption and Production

Fossil fuels meet over 86 percent of world energy needs. Coal has been the fastest growing energy resource globally for the last five years. World reserves of coal total 847,488 million tons oil equivalent (MTOE), which at current consumption rates could last up to 200 years (BP, 2008). Oil consumption rises yearly, though at a slower rate in 2008 compared to previous years, and remains the largest primary energy source. This slower rate is likely due to declining supply in OECD countries and production cuts by OPEC (DOE, 2008). Proven world reserves are 169 billion tons. In 2008, annual production was 3,906 million tons compared to consumption at 3,953 million tons. Not only has consumption outpaced supply, but previously considered economically marginal oil fields such as those beneath seabeds or shale fields are also being brought into production. Natural gas reserves, totaling 177 trillion cubic meters, are seen as a promising alternative to oil production. In 2007, world production was 2,654 MTOE and consumption was 2,638 MTOE. As oil prices rise and supply tightens, many localities are switching to natural gas. Nonetheless, experts predict consumption for that as well will quickly outpace supply (BP, 2008).

Figure 1 shows that global consumption of fuel sources by percentage for 2006. Global energy consumption has increased over time but the proportion has remained fairly constant since 1990. A steady percentage of global energy is derived from civil nuclear power. France is one of 31 countries that use nuclear energy to meet up to 75 percent of their electricity needs. Countries such as Japan, Germany and Finland use nuclear power for a quarter of their power (World Nuclear Association, 2009).

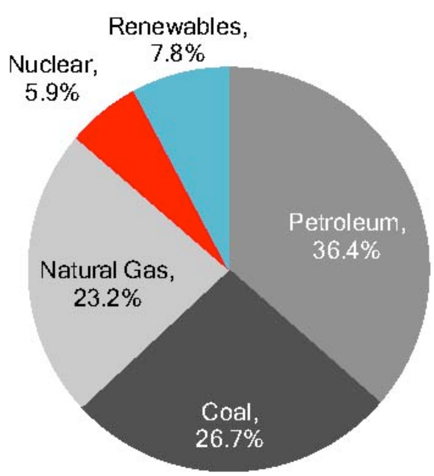


Figure 1. *Global energy consumption by source by percentage, 2006.* (EIA, 2008).

The Energy Information Administration (EIA) (2008) predicts that global energy consumption will increase by 2.4 percent annually, while fossil fuel production will increase at a slower rate. However, renewable sources appear to be the fastest growing source of energy production globally (EIA, 2008). Locations across Asia and Central and South America are increasing their hydroelectric capacities, while countries in Western Europe are developing and implementing wind power programs. Brazil has maintained a sugar cane ethanol program since the late 1970s and has achieved, through government subsidization, some success in its transportation sector.

1.1.2 National Energy Consumption and Production

The U.S. was energy self-sufficient until the 1950s. However, by 2007, the U.S. consumed 21.3 percent of the world's primary energy (EIA, 2008). In the same year, the U.S. contributed only 8 percent of the world's oil supply, but was responsible for 24 percent of the world's oil consumption. Similarly, the U.S. produced 19 percent of the world's natural gas supply, but consumed 23 percent (EIA, 2008). Among five sectors of the economy, 40.6 percent of total energy is dedicated to electric power, 28.5 percent to transportation, 21.4 percent to industrial production, and 10.4 percent to residential and commercial activity. Electric power generation is 91 percent dependent on coal, while the transportation sector utilizes petroleum for 70 percent of its energy (EIA, 2008).

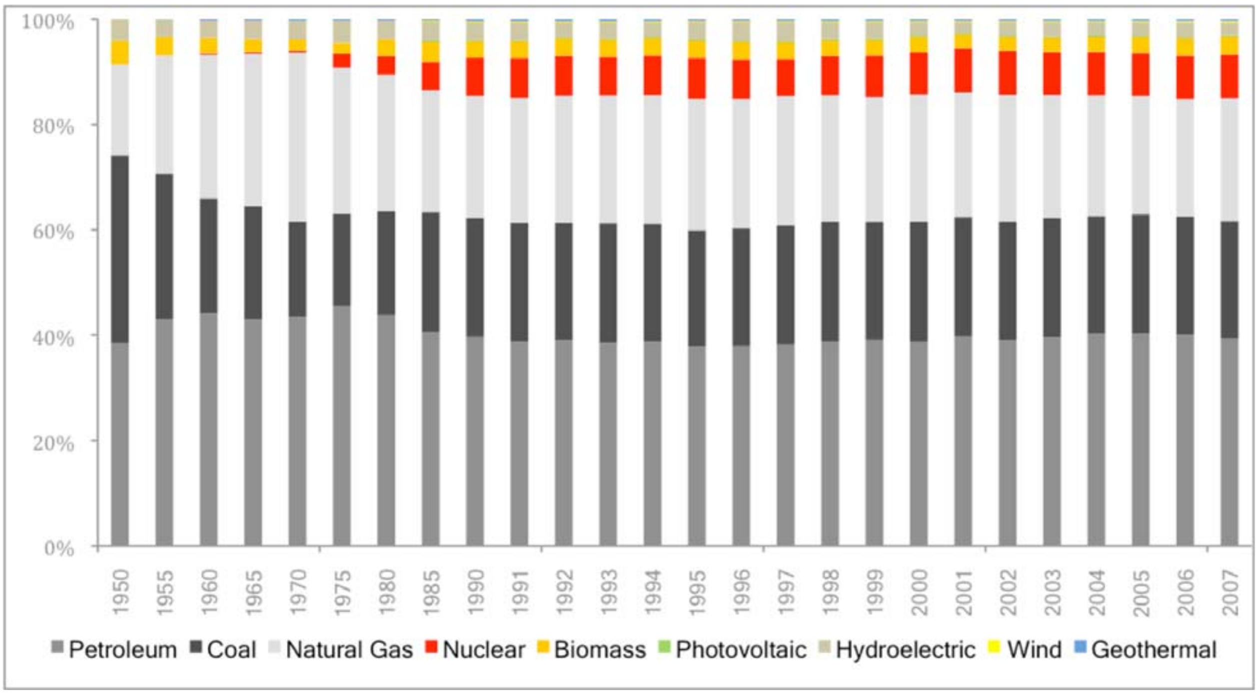


Figure 2. *National primary energy production by source, 2005.* Data are from the Annual Energy Review 2007 (EIA, 2008). Bar graph illustrates the overall reliance on fossil fuels from 1950 to 2007.

Domestically, primary energy consumption is comprised of 39.3 percent oil, 23.3 percent natural gas, 22.5 percent coal, totaling 85.1 percent for energy supplied by fossil fuels (Figure 2). Figure 2 shows the introduction of nuclear power in the 1960s and its quick rise through the 1980s. It has held a steady rate of energy production in the U.S. since the 1990s and in 2007 met 8.4 percent of the country's energy needs. Figure 2 also shows that 6.7 percent of domestic energy is produced from renewable sources, a majority being hydroelectric and biomass with wind power doubling within the last couple of years (EIA, 2008).

Debate over increasing coal consumption centers on the feasibility of "clean coal" technology, CO_2 Capture and Storage, or CCS, which aims to reduce or eliminate polluting side effects (DOE, 2008). Post-combustion and certain types of underground carbon storage sequestration have proven economically feasible, while pre-combustion and ocean storage is still undergoing feasibility research (IPCC, 2005). To date, there is no commercial-scale sequestration. In the US, coal production generated 19 percent of world total and consumption equaled 18 percent of the global coal supply (BP, 2008).

The use of renewable energy sources in the U.S. is expanding. Echoing global expansion in wind and hydroelectricity, the U.S. is building more hydroelectric dams in the Northwest, Tennessee Valley, and along the Colorado River. Wind power currently provides 1 percent of electricity needs but is expanding rapidly. Solar power provides less than 1 percent of the U.S. demand for energy, but should increase as technologies improve and cost becomes less prohibitive. Geothermal energy, seen as efficient and reliable, is used in California, Hawai‘i, Nevada, and Utah, but meets less than 1 percent of energy needs. One aspect of biomass power, in the form of municipal solid waste combustion, provides energy from a renewable source as it helps eliminate waste. Another use of biomass power in the U.S. is liquid fuels, mainly in the form of corn ethanol or biodiesel from recycled cooking grease, vegetable oil or animal fats (EIA, 2008).

1.1.3 Local Energy Consumption and Production – The Case of Hawai‘i

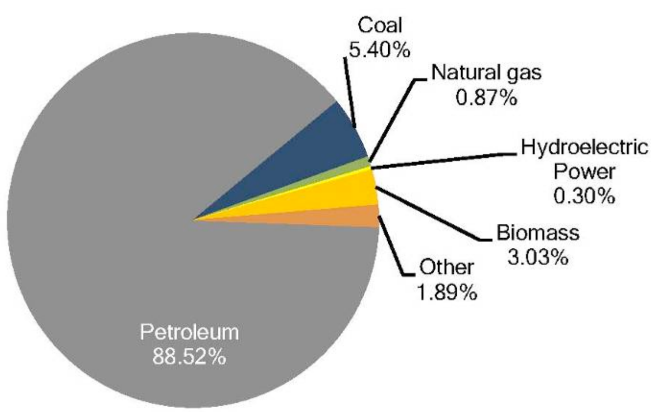


Figure 3. *Hawai‘i consumption of energy by source, 2005.* Data derived from DBEDT State Data Book 2008. It shows the heavy reliance on imported fuel sources such as coal or petroleum. The "other" category represents geothermal, wind, photovoltaic, solar thermal energy, and net imports of electricity. This represents consumption by all economic sectors, including both transportation and electricity.

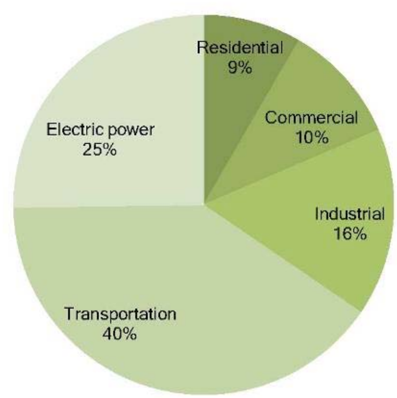


Figure 4. *Hawai‘i consumption of energy by sector, 2005.* Data derived from DBEDT State Data Book 2008, 2005 data were the most current information available.

Unlike the continental US, Hawai‘i depends on petroleum to meet 89 percent of its energy needs (EERE, 2008c). Of the remaining 11 percent, about six percent is derived from other fossil fuel sources, including coal and natural gas. About five percent of Hawai‘i's energy is derived from renewable sources—hydroelectric, geothermal, wind, photovoltaic, solar thermal energy, biomass and municipal solid waste (Figure 3). Figure 4 illustrates energy consumption within the State: transportation (40 percent) and electric power (25 percent), followed by residential (9 percent), commercial (10 percent), and industrial (16 percent) (EERE, 2008c; DBEDT, 2008b).

Electricity Sources and Usage. The State’s two petroleum refineries are located on O‘ahu. Unlike the continental US, where coal is the primary electricity source, Hawai‘i mostly relies on residual fuel oil from petroleum for electricity (DOE, 2008). Hawaiian Electric Industries (HEI) and its subsidiaries, the Hawaiian Electric Company (HECO), Hawai‘i Electric Light Company (HELCO) and Maui Electric Company (MECO), use residual fuel oil and other sources to provide electricity for 95 percent of Hawai‘i’s consumers. HECO provides power to O‘ahu, HELCO to Hawai‘i Island, and MECO to Maui, Lāna‘i, and Moloka‘i. Kaua‘i County relies on a cooperative arrangement for power generation and distribution. Table 1 compares the mix of fuel sources for electricity production by HEI companies, thus not including Kaua‘i. Petroleum is the largest source of electricity generation for all three HEI utilities. While HECO and MECO both depend on biomass for about 4 percent of electricity generation, HELCO has the largest percentage of energy from renewable sources (DBEDT, 2007d).

Table 1
Sources for electricity generation in Hawai‘i, 2007

	HELCO	HECO	MECO	Total
Petroleum	69.1%	77.6%	83.7%	77.4%
Coal		18.4%	1.8%	14.1%
Biofuel			0.1%	
Biomass		4.0%	4.4%	3.6%
Geothermal	18.3%			2.1%
Hydroelectric	3.4%		0.7%	0.5%
Wind	9.2%		9.3%	2.3%

Note: Information is adapted from HECO website discussing the State fuel mix for calendar year 2007. Photovoltaics are not reported because they comprised less than 0.05 percent of electricity generation (DBEDT, 2008b). Solar hot water comprised 1.5 percent (DBEDT, 2008b). Data on Kaua‘i are not included in the total calculation.

Use of Biomass for Electricity. While Hawai‘i’s fossil fuel use has remained proportionately large over time, the use of biomass for energy has decreased significantly (DBEDT, 2008b). Figure 5 illustrates this decrease in use of biomass for energy generation throughout the 1990s, coinciding with the introduction of coal in 1992. In 1962, 18 percent of Hawai‘i’s primary energy was produced by sugar plantations—mainly from biomass-fired electrical generation and some from hydroelectric sources (Alber, Bac, Dorian, Raman, Tantlinger, & Tome, 2000). Less than a decade later in 1970, approximately 10 percent of the State’s primary energy came from biomass, reduced to only 2 percent by 2004 (Alber et al., 2000; DBEDT, 2008b). After the sharp decline of biomass for energy generation in the early 1990s, the State opted to diversify its energy portfolio by increasing the use of coal and municipal solid waste on O‘ahu and geothermal on Hawai‘i Island.

Today, large-scale biomass feedstock for electricity in Hawai‘i includes sugar cane bagasse and municipal solid waste. Before the close of the sugar plantations, local utility companies purchased biomass electricity from the sugar mills. Now, MECO is the only utility with the ability to purchase power from a sugar mill. Hawaiian Commercial & Sugar Company (HC&S) in Pu‘unēnē, Maui supplies 94,027 MWh to MECO, approximately 7 percent of Maui's electricity demand, from its mill and hydroelectric plant (Alexander & Baldwin, 2008). On O‘ahu, the City & County of Honolulu's H-POWER plant has the capacity to produce 57 megawatts of energy, i.e. 5 percent of O‘ahu's electricity demand, from 2,160 tons a day of municipal solid waste (DBEDT, 2008b).

In terms of projects being currently pursued, HECO is developing a new power plant that is permitted to run on biodiesel and will require 5 to 12 million gallons of biodiesel per year (Kalani, 2009). MECO is also using biodiesel in small amounts for start up and shut down operations (MECO Integrated Resource Plan, 2007). In addition, BlueEarth Biofuels LLC and HECO will co-own a biodiesel refinery being built on Maui with a projected generating capacity of 40 million gallons per year. Although projects are being developed to produce biofuels locally, Hawai‘i currently lacks commercially available local feedstock to fuel these operations. As a result, feedstock material that meets the Roundtable on Sustainable Palm Oil Principles and Criteria guidelines will be imported (Natural Resources Defense Council & HECO, 2007). Other plans to expand local biomass for electricity generation include use of existing eucalyptus trees on Hawai‘i Island through several bioenergy companies (see Section 7: *Eucalyptus Plantations in Hāmākua*).

Other Renewable Electricity Sources. The State's concerted effort to expand the use of other renewable energy sources has encouraged a steady increase in solar hot water, more than doubling its contribution to the State's energy resources from less than 0.5 percent in the early 1980s to nearly two percent in 2006 (Figure 5) (DBEDT, 2008b). In 1993, geothermal was introduced on Hawai‘i Island as a local firm power source for electricity generation. Currently, about 30 MW of geothermal power are provided to the HELCO grid, although increases in production are possible (Global Energy Concepts, 2006). Hawai‘i also has numerous hydropower plants located on the islands of Hawai‘i, Kaua‘i, and Maui. The largest in the state is located near Hilo (DBEDT, 2009). Furthermore, wind production increased significantly between 2006 and 2007 due to increases in Maui's Kaheawa Project and Hawai‘i Island's ‘Upolu Point Project. Within the last two years, wind power generation surpassed both geothermal and hydroelectric power generation (DBEDT, 2008b). Finally, wave energy has potential in Hawai‘i but is in developmental stages. One company, Ocean Power Technologies, has been conducting research in Kāne‘ohe, O‘ahu since 2004 (DBEDT, 2008b).

Transportation in Hawai‘i. Transportation in Hawai‘i is heavily dependent on petroleum—62 percent of transportation fuel demand is consumed for aviation, 30 percent supplies ground transportation, and 8 percent fuels marine transportation (DBEDT, 2007a). The same refineries on O‘ahu that produce residual fuel oil for electricity produce liquid transportation fuels, and import and blend ethanol to meet the State's 10 percent ethanol blending mandate for motor fuels (see Section 3: *Policies Affecting Biofuel Production*).

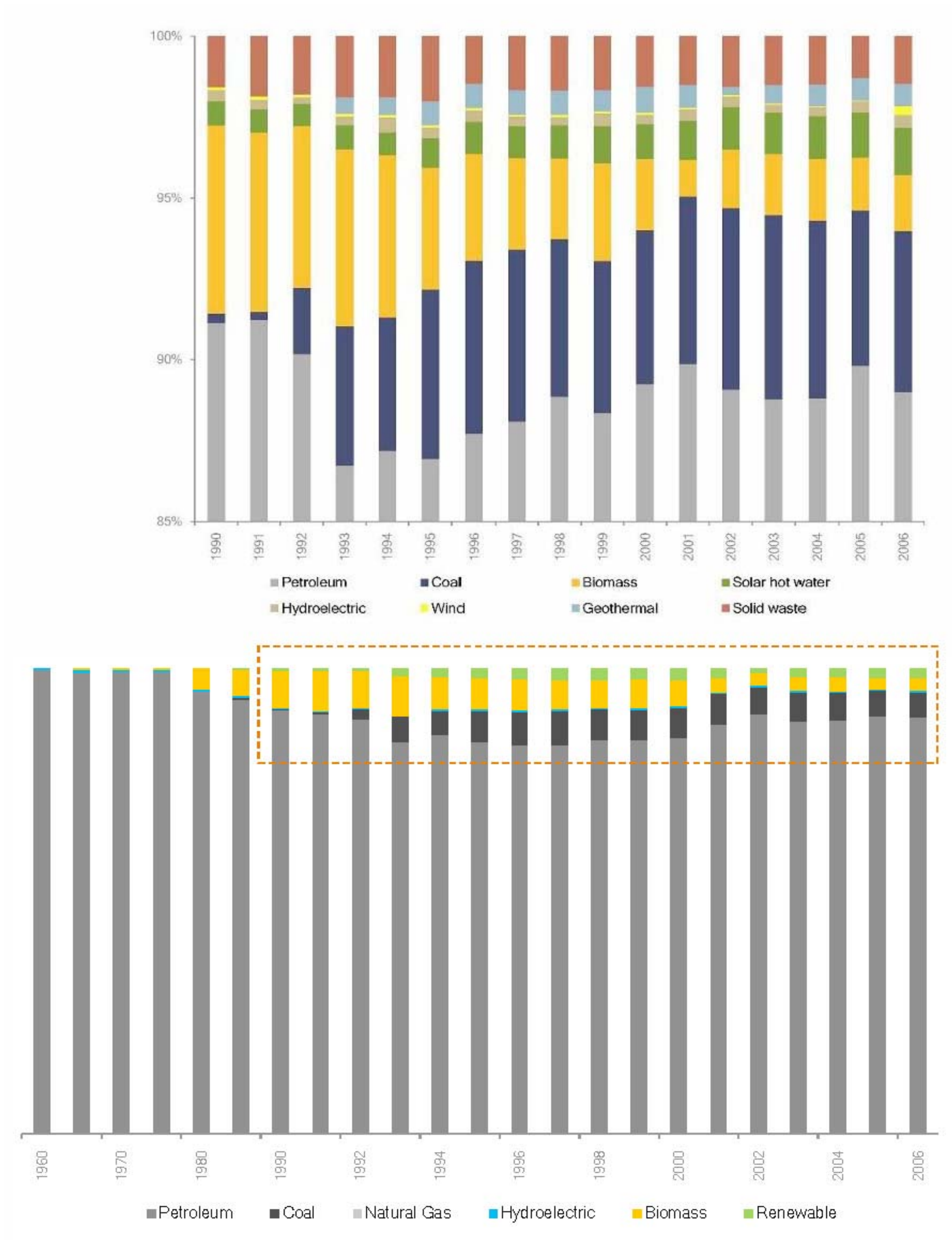


Figure 5*. Primary energy by source in Hawai‘i, selected years 1960-2006.* Information is adapted from the DBEDT State Data Book (2008b) and the Energy Information Agency (2008). Data for renewable energy sources available only after 1990.

Hawai‘i ranks second to Alaska in the quantity of jet fuel consumed per capita. For bunker fuel, which is a type of byproduct from refining crude oil, statewide usage per capita exceeds usage in most other states (EIA, 2009; Surles, Foley, Turn, & Staackmann, 2007). In 2006, highway fuel consumption—including gasoline, diesel oil, and butane gas—topped 500 million gallons (DBEDT, 2007a). This demand has increased at a rate of 1.8 percent, averaged annually, from 1984 to 2006. This may be due to simultaneous increases in population and increases in vehicle ownership (Lem, 2007). In 2007, over 480 million gallons of motor gasoline, 282 million gallons of diesel oil (of which 216 million used for non-highway purposes), and 236 million gallons of jet fuel were sold in Hawai‘i. Of this, about 17 percent of the gasoline and 10 percent of the diesel were sold on Hawai‘i Island (DBEDT, 2007a).

Current Biofuel Use. Locally, between 40 and 50 million gallons per year of ethanol are needed to satisfy the 10 percent blending requirement, and all ethanol is imported to Hawai‘i. Pacific Biodiesel, Inc., a commercial biodiesel operation, locally produces biodiesel from waste restaurant oils on a relatively small scale. The company’s two plants produce a combined 1.75 million gallons of biodiesel a year, and the fuel is sold primarily for ground transportation (Pacific Biodiesel, 2009; EERE, 2009b). By 2005, over 300 gasoline stations and 16 alternative fuel stations were built in Hawai‘i, including seven biodiesel stations (DBEDT, 2007a).

1.2 Land Use - Agriculture and Forestry in Hawai‘i

As an agricultural commodity, a new biofuel industry in Hawai‘i will face the same challenges as current agricultural producers. This section explains the general state of agriculture in Hawai‘i and on Hawai‘i Island by describing the distribution of agricultural land, the economic state of local agricultural production and large historical shifts in the local agriculture industry.

1.2.1 Distribution of Agricultural Land – Hawai‘i and Hawai‘i Island

State of Hawai‘i. Hawai‘i has 7,521 farms on a total of 1,121,329 acres (NASS, 2007). However, the State Land Use Commission has 1,930,224 acres zoned as agriculture, of which the State owns 430,000 (Surles et al., 2007). This means that roughly 806,705 acres, or 42 percent, of Hawai‘i’s agriculturally zoned land is not being used in a farm operation as classified by the U.S. Department of Agriculture (USDA). To qualify as a farm under USDA, the operation must normally produce and sell $1,000 or more agricultural products a year. The caveat of “normally produce and sell” refers to farm operations that may experience setbacks such as a natural disaster or crop diseases (NASS, 2007, p. A-1).

The majority of the farmland in Hawai‘i is in pasture or range, followed by cropland, woodland, and then non-productive land, such as farmsteads or roads. Table 2 describes the distribution of farmland in Hawai‘i and on Hawai‘i Island, along with the percent of each category of land located in Hawai‘i Island. The “total cropland” category includes land that is harvested, used for pasture or grazing, planted in cover crops, cropland in cultivated summer fallow, and is lying idle. It also includes land on which all crops failed (NASS, 2007). Within total cropland, only 44,336 acres (4 percent) are idle or planted in a long-term cover crop. An additional 126,391 acres are not in production due to built structures. In total, Hawai'i has 950,602 acres in agricultural production (NASS, 2007).

Table 2
Distribution of agricultural land (in acres) – Hawai'i and Hawai'i Island
Farm workforce (in number of workers) and average hourly wages (in U$S) – Hawai'i

	HAWAI'I	HAWAI'I ISLAND	% OF STATE TOTAL [1/]
Land zoned Agriculture [2/]	1,930,224	1,214,040	62.89%
Total farms	7,521	4,650	61.83%
Total land in farms (acres)	1,121,329	683,819	60.98%
Total cropland (acres)	177,626	81,837	46.07%
Harvested cropland	103,120	56,310	54.61%
Pasture, grazing	23,493	17,072	72.67%
Other – failed, summer fallow	6,677	1,759	26.34%
Idle, cover crop	44,336	6,696	15.10%
Woodland (acres)	79,041	46,137	58.37%
Pasture, rangeland (acres)	738,271	485,688	65.79%
Farmsteads, ponds, roads, livestock facilities, wastelands (acres)	126,391	70,157	55.51%
Hired farm workers	6,500	2,500	38.46%
Average hourly wage [3/]	12.84		

Note: Adapted from NASS, 2007 and NASS, 2008.
[1/]Percentage column is the percentage of the state total located on Hawai'i Island.
[2/]Surles et al., 2007.
[3/]HDOA, 2007c.

Fallow Land. Fallow land is cropland left idle, but not harvested, pastured, or grazed. It could be bare or planted in cover crops for soil improvement. The discrepancy between statistics reported for unproductive land—approximately 170,727 acres of fallow cropland reported by the USDA versus the 806,705 acres of land within the State agriculture land use district that does not qualify as a farm operation by USDA—is caused by how lands are zoned agriculture by the State.

Hawai'i's land use law, which zones all lands in the state into conservation, agricultural, rural, and urban districts, was created to protect prime agricultural lands from sprawling urban development (Nunns, 1962). However, the agricultural district has become the "catch-all" district because, in addition to productive lands important for agriculture, it also contains all the lands that do not fit into the conservation or urban districts (Callies, 1984). As a result, Hawai‘i's agricultural district contains lands of varying agricultural potential, with no distinction. Some opponents of the current land use law have called for identifying the most important agricultural lands, providing incentives for preserving those lands, and reclassifying the remaining non-important agricultural lands to other existing or new districts (Callies, 1984; Roehrig, 2003; Suarez, 2005). In response, the State adopted legislation to allow landowners to designate Important Agricultural Lands (see Section 3.3.2: *Existing State Policies Impacting Biofuels*).

Hawai‘i Island. Hawai‘i Island has 683,819 acres of land in farms and a total of 4,650 farms, 62 percent of the State's farmland and 61 percent of the State's farmers. Over 70 percent of the farmland on the island is devoted to pasture or range, leaving 12 percent to cropland, another 7 percent to woodland, and the remaining 10 percent to built structures. Out of the island's 81,837 acres of cropland, about 6,696 acres (1 percent) are lying idle or planted in a long-term cover crop. While this seems relatively minimal for the entire island, there is a general perception in Hāmākua that much of the land in the region is not at its best use and thus a feeling that more land is fallow than the numbers reflect. In total, Hawai‘i Island has 606,966 acres in some type of agricultural production (NASS, 2007).

As for the remaining land uses on Hawai‘i Island, about 2 percent of land is classified as urban land use district, 51 percent conservation, and 0.05 percent rural. The island is home to 63 percent of Hawai‘i's total acreage, including 66 percent of the State's land zoned in the conservation land use district, 27 percent of the urban land and 12 percent of the rural land (DBEDT, 2007d). The State of Hawai‘i holds land along the Hāmākua Coast under the Departments of Land and Natural Resources (DLNR) and Hawaiian Home Lands (DHHL). The largest private landowners in the area are Kamehameha Schools, Parker Ranch, and Kūka‘iau Ranch.

1.2.2 Diversified Agriculture in Hawai‘i

Local Diversified Agriculture. Historically, Hawai‘i has produced three categories of agricultural crops: traditional plantation crops, commodities for local consumption, and niche export crops. Agricultural operations tend to cluster in areas of relatively low elevation, high rainfall and well-drained soils, such as Hāmākua. Without sugar and pineapple plantations, production factors have concentrated on developing diversified crops and the market encourages the development of regional specialization (Juvik & Juvik, 1992). By 2006, Hawai‘i's top agricultural crops produced were:

1) Flowers and nursery products (22.1%)
2) Seed crops (21.4%)
3) Vegetables and melons (16%)
4) Macadamia nuts (8.5%)
5) Coffee (8.1%)

Other production includes cattle (5.8 percent); fruits, except pineapple (5.7 percent); aquaculture (4.7 percent); milk (3.2 percent); eggs (1.8 percent); hogs (0.9 percent); and other (1.8 percent)

(NASS, 2007). Hawaiʻi Island has half of the State acreage devoted to flower and nursery products, holds a large portion of the fruit market, and is the leader in local beef cattle production (DBEDT, 2007d).

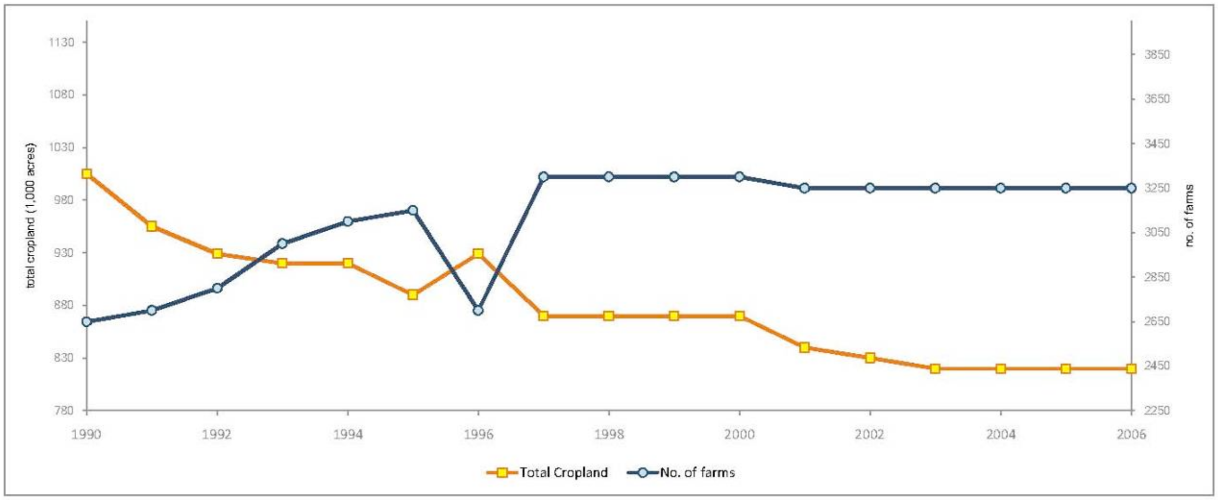


Figure 6. *Number of farms and acres on Hawaiʻi Island, 1990-2006.* This illustrates the trend from 1990 to 2006 of the decrease in total cropland but an increase in the number of farms on Hawaiʻi Island. Acreage includes land zoned as agriculture, but not in production, including farmhouse lots and roads (DBEDT, 2007d).

Shifts in the Agriculture Industry. Figure 6 shows the shift in the number of farms on Hawaiʻi Island and the corresponding acreage from 1990 to 2006. It demonstrates how the end of sugar production on Hawaiʻi Island in the early and mid 1990s, and possibly the rise in non-agricultural land uses, correlates with a decline in the amount of available cropland and encouraged an increase in the number of individual farms. The overlapping drop in the number of farms and rise in available cropland in 1996 coincides with the closing of the last sugar plantation in Hāmākua. The closure of sugar plantations on Hawaiʻi Island in the 1990s—Hāmākua Sugar Company in 1993, Hilo Coast Processing Company in 1994 and Kaʻū Agribusiness Company in 1996—opened up several thousand acres of agricultural land and irrigation infrastructure (Nishimoto, 2004).

Figures 7 and 8 illustrate the value of crop and livestock sales in Hawaiʻi and on Hawaiʻi Island, respectively, from 1990 to 2006. Data for pineapple on Hawaiʻi Island is not public, in order to protect the release of proprietary data for a single operation. Both figures demonstrate the rise of diversified agriculture as sugar and pineapple production decline. Figure 7 shows that acreage devoted to livestock throughout Hawaiʻi has declined slightly, in contrast to Figure 8, which shows that livestock acreage has increased on Hawaiʻi Island.

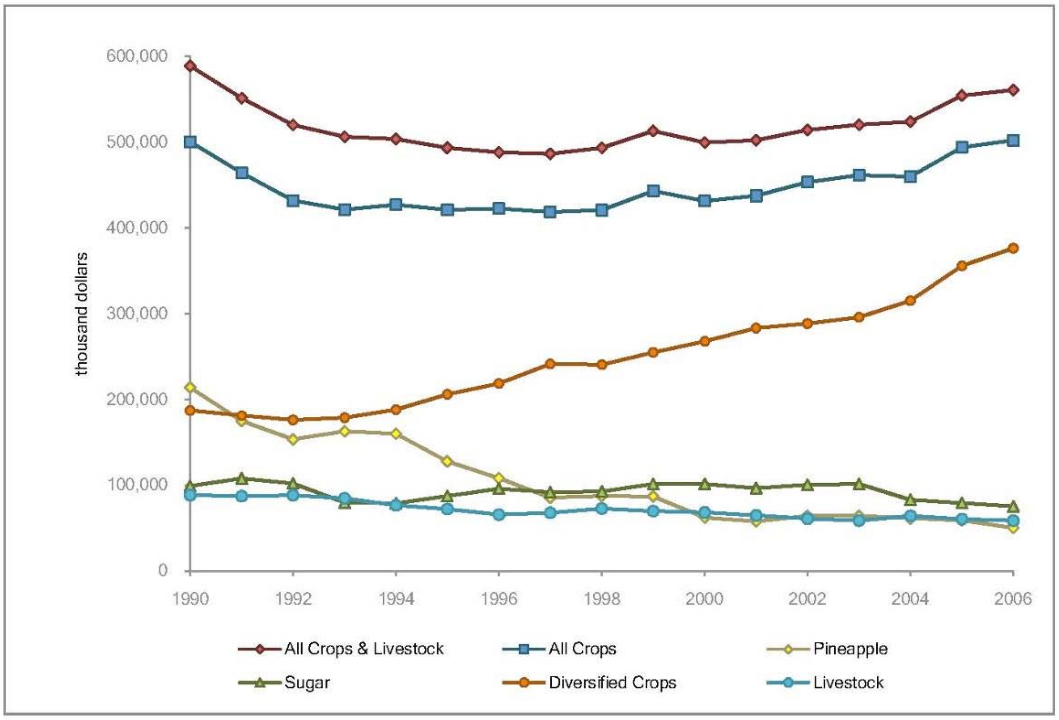


Figure 7. *Value of farms in Hawai‘i, 1990 to 2006* (DBEDT, 2007d).

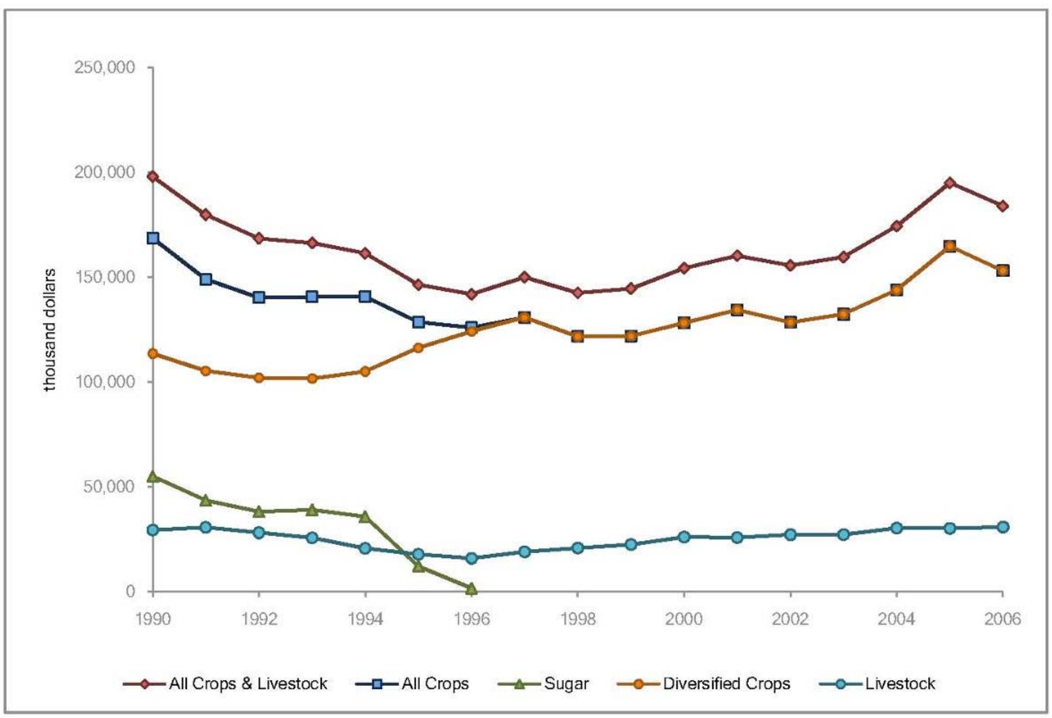


Figure 8. *Value of crop and livestock sales on Hawai‘i Island, 1990 to 2006.* Data for pineapple was not provided as to not release proprietary data for a single operation (DBEDT, 2007d).

1.2.3 Forestry on Hawai'i Island

Hawai'i's forests provide watershed protection, habitat for Hawai'i's unique plant and animal species, and are a place for educational and recreational activities. In addition, forests are used for commercial forestry activities, including hardwood, short-rotation tree crop and production of specialty forest products (Juvik & Juvik, 1992).

In 2001, the forest industry in Hawai'i employed over 900 full time employees with estimated revenues of nearly $31 million. The forest industry included the forest management, wood harvest, and wood products development and distribution of locally grown wood (Yanagida, Friday, Illukpitiya, Mamiit, & Edwards, 2004). The State had approximately 1,109 retail establishments that sold products made from locally grown woods. Hawai'i Island accounted for 23 percent of the State's total retail sales of Hawai'i-grown woods. Koa was the primary wood source. Common koa products include furniture, bowls, musical instruments, and picture frames. Other locally grown woods used in retail products included mango, milo, kou, 'ōhi'a, and eucalyptus (Friday, Yanagida, Illukpitiya, Mamiit, & Edwards, 2006). There was a lack of growth in the forest industry from 1991 to 2001. However, industry expansion is expected to occur in the near term and will be primarily from fast-growing, non-native plantation tree species, not slower-growing trees such as koa. Over 25,000 acres of eucalyptus in Hāmākua and Ka'ū are ready for harvest (Yanagida et al., 2004); the use of the trees is yet to be determined.

2. Biofuels – Feedstocks and Conversion Processes

Liquid biofuels are one alternative energy source to fossil fuels for the transportation sector. Liquid biofuels and biomass can also be burned to generate electricity in a manner that can be accommodated with only minimal changes to our current electricity generation and distribution system. The burning of biomass for electricity generation is similar to the burning of municipal solid waste, currently used as a feedstock at H-Power on O'ahu. Smaller, on-site generation units are possible on farms to generate electricity locally. This section discusses the potential biofuel feedstocks and conversion processes that are applicable to Hawai'i.

2.1 Biofuel Feedstocks

Biofuel feedstocks can be grown for the primary purpose of creating energy, or can be generated as a byproduct of some higher-value product (see Section 4.1: *Environmental Benefits of Diversification*). Biofuel feedstocks can be chosen by capacity to store energy in the form of oil, sugar, starch, or plant fibers. All of these storage materials can undergo conversion to create liquid or gas biofuels.

Biofuel feedstocks are often described as either first, second or third generation technology. First generation biofuel feedstocks are crops that are currently being produced and manufactured into biofuels. As such, these feedstocks tend to be food sources, with known yields and existing commercial conversion technologies. Second generation biofuels are those that are made from feedstocks that are residual materials left after production of a main product. These fuels often require cellulosic conversion, such as in the case of ethanol. Third generation biofuels are those that are presently in the research and development stage. These feedstocks are grown exclusively for energy purposes and require advancements in technology or crop research before reaching the commercial markets (Biomass Research and Development Board, 2008).

Common Feedstock Species. When choosing a biofuel feedstock, the end use of the biofuel must be considered. The following are some of the plant species being used or considered for biofuel production in Hawai‘i, though there are many other possibilities. Input requirements and environmental conditions for growth, such as climate, soil and sun exposure vary among species. Feedstock yields will vary given the feedstock exposure to inputs and growth requirements.

Grasses:

- Sugar/energy cane (*Saccharum officinarum)* is a common crop originating in the South Pacific, but has been cultivated in Hawai‘i for over 150 years. Energy cane and sugar cane are the same plant. Energy cane refers to the harvesting of the entire plant for use as a feedstock, while sugar cane is harvested just for the sugar. The highest sugar yields occur on irrigated fields (Wiedenfeld, 1995).

- Banagrass and Napier grass *(Pennisetum purpureum)* originated in tropical Africa and are some of the highest yielding tropical forest grasses. These grasses are the same species– napier grass is a modified, larger version of banagrass. Both require considerable nitrogen for high yields (El Bassam, 1998).

- Guinea grass (*Panicum maximum)* is a non-native grass and very little is known about its local yields (Daehler, 1998).

Trees:

- Eucalyptus (*Eucalyptus sp*.) is native to Australia. Many different species are present locally, though *Eucalyptus grandis* is the most common species currently being grown on Hawai‘i Island. Eucalyptus can be grown in low-nutrient conditions, but yields increase when nutrients are plentiful (El Bassam, 1998).

- Oil palm (*Elaeis guineensis)* is originally found in West Africa, and is being considered for the high oil yields in its fruit, which can be used to make biodiesel (El Bassam, 1998). Site selection is important for oil palm, since it requires higher rainfall or more irrigation than other tree species. Genetically modified variants are being considered for Hawai‘i-specific production, as current production is restricted to latitudes within less than 10 degrees of the equator and elevations of less than 500 meters (El Bassam, 1998).

- Kukui (*Aleurites moluccana*) is an aboriginal introduction to Hawai‘i. Biodiesel can be derived from its oil, though the high value of kukui nut oil may mean that biofuel is not its most economical use. The rest of the biomass can also be used as feedstock for other biofuels (Poteet, 2006).

- Jatropha (*Jatropha curcas)* is being considered for biodiesel production because of the high oil content of its fruit. It is a nitrogen-fixing tree, thus reducing its required inputs.

It is toxic, however, making it a potential hazard. Jatropha is currently being produced in parts of India, the Philippines, and other countries, but yield data for Hawai‘i is not yet known (Poteet, 2006).

- Leucaena (*Leucaena leucocephala)* is found originally in Mexico and Central America. It is a nitrogen-fixing plant, like Jatropha, but it is relatively non-toxic and highly digestible (El Bassam, 1998).

Algae:
- Though not all species of algae are plants, algae are often mentioned as potential feedstocks because of their ability to make and store oil. Algae can be cultivated in salt and brackish water, which is an attractive characteristic because of the ample salt water available in Hawai‘i (Howell, 2009).

2.2 Conversion Processes

Conversion technologies vary depending on the type of biomass stock and the type of fuel being processed. The following figure illustrates the types of conversion technologies and their respective fuel products and common functions.

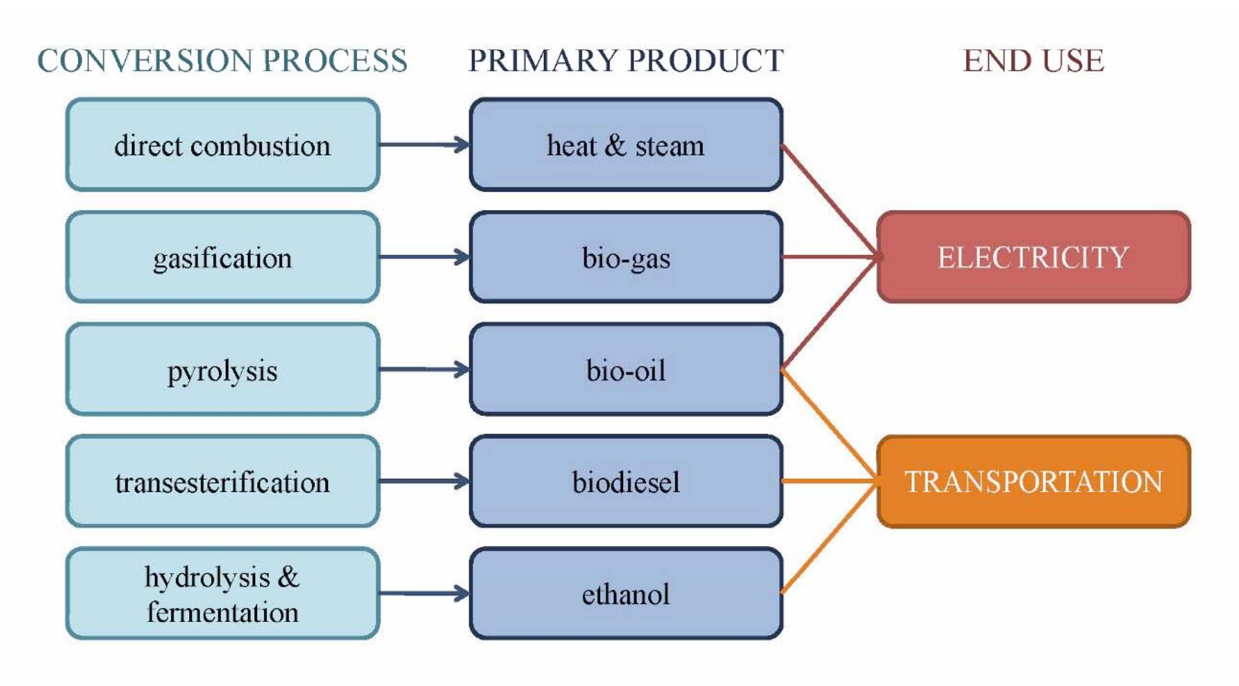


Figure 9. *Biofuel conversion processes, products and end uses.*

Direct Combustion. The combustion of biomass as a fuel for cooking and heating is the original use of biomass for energy. Large-scale combustion can be used for steam generation to generate electricity and power. Industrial biomass combustion operations burn wood, agricultural residues, wood pulping liquor, municipal solid waste (MSW) and refuse-derived fuel (Demirba, 2001).

Biomass can be combusted in either a furnace or a boiler. In a furnace, biomass burns in a combustion chamber and the resulting hot gases contain about 85 percent of the potential energy previously stored in the biomass. Commercial and industrial facilities use furnaces for heat either directly or indirectly through a heat exchanger in the form of hot air or water. If biomass is combusted in a boiler, the boiler transfers the heat of combustion into steam, used for electricity, mechanical energy or heat. The steam output contains 60 to 85 percent of the potential energy previously stored in the biomass (Demirba, 2001).

Ethanol – Hydrolysis and Fermentation. Ethanol is a fuel derived from the sugar, starch or cellulose of plant matter through hydrolysis and fermentation. First generation biofuel feedstocks for ethanol rely on a combination of hydrolysis and fermentation. Hydrolysis breaks down the complex sugars and starches in biomass and uses water to convert it into glucose, as simple sugar. The glucose is allowed to ferment into ethanol using yeast or bacteria, and then the ethanol is distilled (State of Oregon, 2007).

Ethanol can also be produced from cellulosic and lingo-cellulosic materials, which are more abundant, lower-valued, and less desirable for other uses than the sugar or starch portions of biomass. Cellulose is the fibrous carbohydrate in cell walls that provides rigidity to plant cells. Lignin is a non-carbohydrate polymer that further strengthens plant cells by binding cellulose fibers in wood and plant walls (Raven, Evert & Eichhorn, 2003). Ethanol production from such materials involves more processing, as the sugars produced from the hydrolysis of cellulose, mostly xylose, are also more difficult to ferment than the glucose typically used by the food industry. Furthermore, some portions of cellulose are 5-carbon sugars, as opposed to the standard 6-carbon sugars, which require a different type of bacteria to ferment. The enzymes for cellulose hydrolysis and the bacteria for pentose fermentation need to be further developed to increase efficiency (Olsson & Hahn-Hägerdal, 1996).

Biodiesel – Extraction and Transesterification. Biodiesel is a fuel derived from oils from vegetables, fruits, animal fats or recycled greases – bio-oils. As a transportation fuel, biodiesel produces less carbon monoxide, hydrocarbons, particulates and other air toxins than diesel from fossil fuel (Morris, Pollack, Mansell, Lindhjem, Jia, & Wilson, 2003). Biodiesel production from plant seeds and fruits requires two main steps: extraction and transesterification. Over 350 oil-bearing seed crops have been identified, though only a few are currently considered for energy conversion (Barthet, 2002).

Bio-oil extraction is a physical process that removes the plant oil from the seeds using pressure or from fruits through boiling, though the use of oils seeds has been studied in greater detail. Industrial plant oil harvesting can also be done through chemical processing by exposing seeds to solvents like hexane, petroleum ether, chloroform, and methanol (Barthet, 2002). The first step for industrial oil harvesting involves removing extraneous materials from the seeds or fruit. Seeds are then cracked, dried, rolled into flakes, then pressed or exposed to solvents. If seeds are exposed to solvents to harvest oil, the solvent is separated from the oil and the extraneous seed materials are called cake or spent flake. Solvents are collected for reuse and spent flake can be used as fuel. Finally, the oil is physically or chemically refined to remove unwanted materials that could make combustion or further use difficult (Hyphoma, 2008).

Bio-oil can also be extracted using pyrolysis, which is currently in the experimental phase. Pyrolysis involves rapid heating of the plant material in the absence of oxygen, which separates the biomass into liquids, gases, and char. The ratio of these products depends on the temperature, level of water vapor present and the speed of the process—high temperature with more vapor favors gas product, while low temperature favors char, and higher temperature with little vapor produces more bio-oil (Bridgwater, 2006). Pyrolysis can be used to transform any type of biomass into a biofuel product, so this functional diversity makes it useful in the biofuel production process. Fast pyrolysis, with high temperature and little vapor, produces a storable fuel that is more easily transported than the biomass itself. The resulting bio-oil requires further refining before use (Faaij, 2006). Char products can be burned to provide the heat required for the pyrolysis process, minimizing both the inputs and the amount of waste produced.

After extraction, bio-oil can be the raw material for several types of biofuel, including biodiesel. Biodiesel production requires that the bio-oil undergo transesterification—the chemical conversion of triglycerides in the oil to the alkyl esters that make up crude biodiesel. The process requires that the reaction take place under high heat and with the aid of a strong base catalyst, like sodium hydroxide or potassium hydroxide. The crude biodiesel product is then refined for use as biodiesel. Glycerin is another byproduct of the reaction, and when water and alcohol are removed, the crude glycerin can be used in pharmaceuticals and cosmetics (Van Gerpen, 2005).

Gasification. Gas and char, like the products of lower-temperature, higher-vapor level pyrolysis, can be used for the creation of other types of biofuels through gasification. Gasification is a multistep process that involves creating char from dry biomass through pyrolysis, then allowing an oxidant gasification agent to react with the char to create a combustible gas product. This new bio-gas contains carbon dioxide, carbon monoxide, methane, hydrogen, and water. Char, tar and trace amounts of other hydrocarbons are also byproducts of the reaction. The tar and char products can be burned for heat generation to fuel the gasification process. Another gasification method, called indirect gasification, uses a non-oxidizing gaseous agent, like steam, in an oxygen-free atmosphere. While it requires an external energy source, this method is sometimes favored over direct gasification because the product contains less oxygen and more hydrogen (Belgiorno, 2003; Bridgwater, 2006). Gasification is currently used to create combustible gases from coal and other fossil fuels, and has been used with fossil fuel feedstocks since the 1900s to provide electricity and synthetic fuels.

There are a few mechanisms to create synthetic fuels from the products of gasification. The Fisher-Tropsch process is one method that can be used to create liquid transportation fuels from the bio-gas (Faaij, 2006). Industries are currently using the Fisher-Tropsch process to convert coal, natural gas, biomass, or mixtures of feedstocks into cleaner burning fuels but production is limited to certain circumstances given high costs (particularly when biomass sources are used) and the need for more research and development (Vliet, Faaij & Turkenburg, 2009; Dry, 2004).

3. Policies Affecting Biofuel Production

There are numerous policies at the international, national, and state level that affect the production, use, research and development of biofuels. As consensus toward using renewable energies grows, more policies are being developed. The European Union is a world leader in renewable energy, and has created numerous policies to support their clean energy goals. President Barack Obama's administration, in addition to previous administrations, has issued several directives and allocated millions of dollars in support of renewable energy. Locally, studies have been conducted, laws have been passed, and agreements have been signed in an attempt to make Hawaiʻi a leader in clean and renewable energy. This section details global, national and state policies that support and potentially impact biofuels.

3.1 Global Policies

International policies related to biofuel production and consumption fall into three major categories: budgetary support measures, blending or use mandates, and trade restrictions (OECD 2008). Budgetary support measures include tax concessions for biofuel producers, retailers, or users; direct support to biomass supply, output, blending, infrastructure; or equipment for users. European Union (EU) Directive 2003/96/EC allows the application of tax incentives for biofuels. As part of the Common Agricultural Policy, the EU's Energy Crop Aid pays €45 per hectare for crops used for energy generation.

Blending or use mandates require biofuels to represent a minimum share or quantity, often in the transportation fuel market. EU Directive 2003/30/EC, the "European Biofuels Directive," promotes a biofuel market in the EU by setting a voluntary "reference target" of 2 percent biofuel consumption (on the basis of energy content) by 2005 and 5.75 percent by 2010 (OJEU, 2003). EU Directive 2003/17/EC establishes environmental standards for petroleum and diesel fuel with 10 miles per kilogram maximum sulfur content (Europa, 2008).

Trade restrictions, mainly in the form of import tariffs, protect the less cost-efficient domestic biofuel industry from competition from lower-cost foreign suppliers. For example, the Everything but Arms Initiative (The Levin Institute, 2008), would allow African countries to export ethanol duty-free into the EU. This could squeeze out EU ethanol production. Trade restrictions protect the market for domestic biofuel producers. However, implementing these trade restrictions often results in higher domestic biofuel prices and thus hurts consumers (OECD, 2008). In the EU, European ethanol is subsidized by offering tax-exemptions for producers. The EU is also considering banning the production of some types of biofuel crops to ensure that the biofuel production is environmentally sound—this includes protecting rainforests. In addition, the EU is considering a tracking system to assess sustainability criteria (The Levin Institute, 2008).

An alternative example of international biofuel trade and restrictions is the recent partnership between Brazil and the US. Brazil and the U.S. are the world's biggest ethanol producers; combined, these countries produce 70 percent of the world's ethanol. In March 2007, the two countries entered into a strategic partnership, which made ethanol an internationally traded commodity and supported its production in Central America and the Caribbean. However, the two countries remained at odds over a 54-cent per gallon U.S. tariff on imported ethanol (BBC News, 2007). In addition to international-level ethanol trade restrictions and partnerships, the U.S. has many domestic bioenergy policies aimed at fostering bioenergy production and consumption (Wong, 2007).

3.2 National Policies

Bioenergy is one component of a broader national energy policy to reduce dependence on foreign sources of energy and greenhouse gas (GHG) emissions. The Biomass Program under the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy (EERE) is the major federal-level program focused on developing biofuel, bioproduct and biopower technologies (EERE, 2009a).

National support for bioenergy production includes the entire biomass-to-biofuels supply chain. The five-part production chain includes 1) feedstock production, 2) logistics, 3) biofuel production, 4) distribution, and 5) end-use. Through targeted research, development, and demonstration, the EERE Program aims to create “a viable, sustainable domestic biomass industry that produces renewable biofuels, byproducts and biopower, enhances U.S. energy security, reduces our dependence on oil, provides environmental benefits including reduced GHG emissions, and creates economic opportunities across the nation” (EERE, 2009a, p. 1).

The Biomass Program is centered on using domestically-produced biomass for liquid transportation. Biomass is a near-term alternative to oil with a huge potential market, since 70 percent of U.S. transportation fuel currently comes from oil. The Biomass Program focuses on cellulosic ethanol to help diversify the available feedstock used to produce biofuels and to reduce price pressure on corn and soybean commodities (EERE, 2009a).

Executive Orders. A few Federal Executive Branch actions have recently impacted bioenergy. The Advanced Energy Initiative, proposed in the 2006 State of the Union, called to enhance energy security, lower U.S. dependence on foreign oil, and improve energy efficiency. The initiative also aimed to make cellulosic ethanol cost competitive with corn-based ethanol in the near-term. The “20 in 10” Plan, proposed in the 2007 State of the Union, aimed to reduce U.S. oil consumption by 20 percent in 10 years, while simultaneously increasing the use of renewable and alternative fuels. Signed in January 2007, Executive Order 13423 required U.S. agencies with 20 or more vehicles to decrease petroleum consumption, and increase alternative fuel use. Executive Order 13432, signed in May 2007, required increased cooperation and coordination among select federal agencies to protect the environment from greenhouse gas emissions related to vehicles (EERE, 2008a).

Legislation. The Energy Independence and Security Act (EISA) of 2007 is another Federal Legislative Branch action that has recently impacted bioenergy. EISA set renewable fuel standards (RFS) to 36 billion gallons per year by 2022. The EPA Act of 2005 strengthened incentives for the production and purchase of bio-based products. The American Jobs Creation Act of 2004 extended the tax credit for fuel ethanol and created tax incentives for biodiesel fuels.

The 2002 Farm Bill supported renewable energy projects through federal procurement, grants, loans, and research and development (R&D) funding. Finally, the Biomass R&D Act of 2000 created the Biomass R&D Initiative to coordinate and accelerate all Federal biomass research and development (EERE, 2008a).

The 2009 Farm Bill has appropriated $243 million of mandatory funds specifically to increase the production of biomass energy. For example, $75 million of mandatory funding and $150 million of discretionary funding was appropriated for bio-refinery assistance (Farm Energy, 2009). Additional funds have been appropriated for: bio-based market programs; biomass research and development; feedstock flexibility programs; and biomass crop assistance (Farm Energy, 2009).

The Obama Administration. The January 2009 inauguration of the Executive Branch has impacted bioenergy, though it is too soon to determine the size of the impact. President Obama has shown his support for clean renewable energy and his desire to decrease America's dependency on oil. On February 5, 2009, during the President's first visit to the U.S. Department of Energy, he said the American Recovery and Reinvestment Act (ARRA) would "begin to end the tyranny of oil in our time" (US DOE, 2009, p. 2). The Act, whose primary objective is to stimulate the economy, will also help to spark the creation of a clean energy industry (US DOE, 2009). The $787 billion ARRA includes $16.8 billion for EERE programs and initiatives. It also provides grants, loans, and tax incentives for renewable energy facilities, renewable energy production, and other energy infrastructure. A sum of $800 million is also appropriated for the applied research, development, demonstration, and deployment of biomass (EERE, 2009c).

3.3 Local Policies: The Case of Hawai‘i

3.3.1 State of Hawai‘i's Position on Biofuels

For the past few years, the State of Hawai‘i has pursued aggressive renewable energy goals and strategies both through the Legislature and Governor Linda Lingle's Administration. In 2006, the State Department of Business, Economic Development and Tourism (DBEDT), which houses the State Energy Office, co-hosted a Bioenergy Workshop focusing on "speeding the expansion of Hawai‘i's bioenergy industry by bridging the gap between policy and implementation" (DBEDT, 2006, p. 1). The workshop was a part of the Governor's *Energy for Tomorrow* initiative, which included the establishment of a 20 percent alternative fuels standard by 2020 and Hawai‘i Renewable Energy Tax Credits with Act 240.

The year 2006 was important for biofuels, with significant action regarding biofuels policy. In addition to the Workshop, the Legislature passed an Alternative Fuel Standard law of 20 percent by 2020. A House Concurrent Resolution encouraged Hawai‘i's landowners, investors, county governments, and regulated electric utilities to pursue development and conversion of fuel crops for electricity generation and the convening of the Hawai‘i Biofuels Summit, which brought together bioenergy stakeholders to discuss the potential growth of Hawai‘i's biofuels industry.

Between 2007 and 2008, federal and State officials have expressed support and interest in developing bioenergy in Hawai‘i. As a result of this support and following the Summit and Workshop in 2006, Act 253 was passed, tasking DBEDT to develop a Bioenergy Masterplan, which is currently under development with the assistance of the Hawai‘i Natural Energy Institute (HNEI). Other policy action, such as Act 234 in 2007, which requires Hawai‘i to limit greenhouse gas emissions to 1990 levels by 2020, also impact the State's pursuit of alternatives to fossil fuels (see Section 4.2: *Greenhouse Gas Emissions*).

3.3.2 Existing State Policies Impacting Biofuels

Since biofuels are generally produced from plant crops, other policy arenas also impact biofuel production and usage. Other areas that affect biofuels include: *agriculture*, in terms of preserving important agricultural lands and avoiding food versus fuel opportunity costs; *environment*, such as encouraging sustainable agricultural production, protecting the environment and integrating biofuels and byproducts into the agricultural sector; and the *economy*, through potentially diversifying and growing the economy (Rocky Mountain Institute, 2006). These relationships are discussed in more detail in other sections of the report.

Renewable Portfolio Standard. One of the major policies impacting the use and production of biofuels is the Hawai‘i Renewable Portfolio Standards (RPS) instituted in 2004, which require that 20 percent of "net electricity sales come from renewable energy by 2020" (Rocky Mountain Institute, 2006, p. 2). This policy is supported by a number of other tax credits and incentives. For example, producers of biofuels are eligible for a tax credit that provides 30 cents per gallon of ethanol (Rocky Mountain Institute, 2006). Preference is also given for purchase of biofuels in State contracts and State procurement policy requires that "an escalating percentage of purchased and leased State vehicles to be energy-efficient, beginning at 20 percent of new vehicles in 2006 and increasing to 75 percent," with energy-efficient vehicles including vehicles that are capable of using ethanol and biodiesel (Rocky Mountain Institute, 2006, p. 60). HRS 237-27.1 allows alcohol fuel sold for consumption or use by the producer to be exempt from State excise tax.

Other Major State-level Policies. Policies that assist potential companies who are interested in developing biofuels in Hawai‘i include:

- Act 208, SLH 2008: Establishes a full-time, temporary renewable energy facilitator position within DBEDT to assist renewable energy producers in pursuing renewable energy production projects.

- HR 221, SLH 2007: Requests DBEDT to investigate the potential of streamlining the biofuels development process by consolidating the permit process for renewable energy producers.

- Act 159, SLH 2007: Allows biofuel processing facilities as a permitted use in an agricultural district and establishes an Energy Feedstock Program, which includes feedstock to be used for biofuels. This Energy Feedstock program coordinates State actions, acts as an information clearinghouse, seeks federal funding, and coordinates research and development projects.

- Act 221, SLH 2001: Establishes a High Tech Business Investment Tax Credit, which provides five years of tax credits at varying rates for a qualified high technology business, including research related to non-fossil fuel energy-related technology. However, this act was significantly amended by the 2009 Legislature with SB199, which passed and is expected to be signed by the Governor. SB199 establishes a temporary 80% tax credit cap and restricts carryover credits for the high technology business investment tax credit and the technology infrastructure renovation tax credit for investments made after May 1, 2009 and ending before January 1, 2011. It also removes the partner distributive share tax incentive.

Additionally, in 1994 a mandate requiring blending of 10 percent ethanol in 85 percent of motor fuel sold was introduced, but was not implemented until April 2006. In 2006, it was estimated that approximately 40 million gallons per year of ethanol would be imported for at least a year. A number of studies on local ethanol production potential were commissioned by the State to begin addressing the lack of local ethanol supplies (Surles et al., 2007). Facilities that produce ethanol have subsequently been announced, but none have materialized. As a result, the blending mandate has been met with imported ethanol. In November 2007, Cargill imported nearly 3.5 million gallons of fuel from El Salvador for Shell Oil and Chevron in Hawai‘i (Ethanol Producer Magazine, 2008).

Important Agricultural Lands. Legislation on Important Agricultural Lands (IAL), Act 183, was adopted in 2005 to catalog and protect lands deemed fit for agricultural production. It states that Hawai‘i has a substantial interest in maintaining an agricultural industry and therefore provides for lands to be classified as “important agricultural land” through either a declaration of the Land Use Council or a county-determined processes. Lands classified as IAL are

- Capable of producing sustained high agricultural yields according to accepted best practices;

- Contribute to the State’s economic base and produce agricultural products for local or export purposes;

- Are necessary to promote a sustained agricultural industry (HDOA, 2008).

The purpose of the IAL designation is “to conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency and assure availability of agriculturally suitable land” (HDOA, 2007b, p. 1 lines 6-9). The primary protection mechanism is to establish a more stringent criterion to rezone lands that have been classified as IAL to another zoning designation, such as urban. Also, the Act calls for agricultural incentives to encourage landowners to classify their lands as IAL. The development of IAL is expected to occur over many years, with the current timeline projecting to finalize maps with IAL designations in 2020.

3.3.3 Hawai‘i Clean Energy Initiative (HCEI)

On January 28, 2008 the U.S. Department of Energy (DOE) and State of Hawai‘i signed a long-term Memorandum of Understanding (MOU) to establish the Hawai‘i Clean Energy Initiative (HCEI). HCEI is a federal and state, public and private, partnership aimed at shifting Hawai‘i's energy system from one that is fueled primarily by oil to one that is powered primarily by renewable energy. The aim is to have 70 percent of Hawai‘i's energy needs provided by renewable energy sources by 2030. Focus areas of HCEI are transportation, energy efficiency, power generation, power delivery, technology integration, sustained financing, and policy and regulatory mechanisms. Recently, the HCEI transportation focus area established an energy growers working group (US DOE, 2008).

Under the MOU, the State of Hawai‘i will have specific roles and responsibilities. Joint roles and responsibilities are to agree on near team goals, develop a set of intended outcomes, designate points of contact for collaboration, produce a strategic plan, and facilitate stakeholder awareness. DOE responsibilities are to serve as the conduit between the State and appropriate organizational entities, designate a lead for necessary working groups, provide technical assistance, and facilitate participation of national, non-governmental entities. The State has to identify state-based stakeholders, establish state-mandated processes, promote the goals and recommendation of the working groups, and develop the necessary technical and economic tools (EERE, 2008b).

As part of HCEI, in October 2008, the Hawaiian Electric companies, the Governor of the State of Hawai‘i, DBEDT, and the State of Hawai‘i Consumer Advocate signed an agreement as a commitment to "accelerate the addition of new, clean energy resources on all islands" (HECO, 2008, p. 2). In this agreement, the Hawaiian Electric companies "commit to pursue and integrate as much as an additional 1,000 MW of renewable energy resources on O‘ahu including approximately 400 MW of wind power from Lāna‘i or Moloka‘i; 60 MW on the Island of Hawai‘i; and 50 MW on Maui" (HECO, 2008, p. 2). An example of a specific near-term biofuel project is the approximately 22 MW of firm power generation on Hawai‘i Island from Hū Honua Biomass (Thompson, 2009).

3.3.4 Potential Upcoming State-Level Policies

While many HCEI-related bills were introduced during the 2009 Legislative Session, most did not survive. However, the near future may include additional attempts to institute policies that will make agreements within the MOU supported by State law. One bill that passed in the 2009 Legislative Session is SB 50, a bill crafted as a direct result of potential renewable energy leases in Hāmākua. This bill amends the current DLNR policy on renewable energy lease agreements by requiring DLNR to conduct public hearings prior to awarding a lease of public land to a renewable energy producer. It also requires that new leases for renewable energy producers do not reduce the land productivity for existing lessees by more than 25 percent.

Another relevant bill is HB591. This provides preferential rates for purchasing renewable energy (including biomass) that is produced in conjunction with agricultural activities, and used to power the activities. Additionally, one energy omnibus bill passed, HB 1464. This bill establishes energy efficiency portfolio standards, increases renewable portfolio standards, and requires energy efficient state buildings.

Hawai‘i has also received about $26 million from the ARRA. The State plans to use this money to prioritize projects, such as an environmental impact statement (EIS) for an undersea cable connecting O‘ahu and Maui County, renewable energy solicitation, and decoupling of utility revenue from utility sales. Hawai‘i also has access to $300 million in competitive grants for an alternative-fueled vehicles pilot program and $2.5 billion in research and development. Tax credits include an extension of the federal tax credit for electricity produced from renewable energy (biomass) to 2014 and various investment credits. Also, there has been a repeal of credit limitations for renewable energy properties and credits for alternative fuel pumps and numerous bond and loan guarantees (Office of the Governor, 2009).

These new and strengthened initiatives will have tremendous implications for the production and use of biofuels in Hawai‘i, because it provides much of the necessary resources and government support that may have been inadequate in the past. Particularly important would be the realization of the undersea cable. If the project were implemented, intermittent power, such as wind, could be transported from neighbor islands to the urban core of O‘ahu. This would increase the resiliency of the electric grid and potentially reduce the need for firm, transportable power such as biofuels.

PART II: Arguments Surrounding Biofuel Production and Use

Though biomass has been used as a fuel source for millennia, modern society has debated its integration into current energy infrastructure. The specific motivations for integration include diversification of energy sources, the potential for closed-loop utilization of plants and land, greenhouse gas emission reduction, and rural economic development. Concerns include the potential detrimental effects of expansion of agricultural production, including crop invasiveness and genetics, and the necessary modification of distribution and end-use infrastructure. The impacts, both positive and negative, of biofuel production and use vary depending on the specific conditions of growth, processing, and end-use. In order for biofuel to be a viable fuel source, the positive effects of biofuel production and use must outweigh the negative consequences. Though many of the specifics will not be discussed here, as this is meant to serve as an overview of pertinent arguments, the scale of biofuel production and end-use plays a role in the magnitude of impacts. Thus the chosen scale of biofuel production for Hawai‘i has a role in the magnitude of both benefits and costs for Hawai‘i.

Biofuel production can be categorized into three scales: (1) smallholder production for local markets (typically defined as an urban or county area); (2) smallholder production with commercial processing for sale to national or international markets; and (3) medium- and large-scale commercial production for national and international markets (Milder, 2008). Each of these scales presents different risks and opportunities from environmental, economic, and social perspectives. Smaller scales have the potential of wider spread local social benefits, present lower environmental impacts, and have the potential of lowering risks by diversifying (Milder, 2008; Gordon, 2008). Yet, there are benefits of larger scales of production because they have the potential to take advantage of economies of scale; that is, of decreasing production costs as output increases, possibly decreasing biofuel costs to the consumer and therefore capitalizes on their competitiveness. However, there is evidence, from industrialized countries, that the cost of producing biofuels may remain high even at larger scales of production (Ryan et al., 2006; in Peters and Thielmann, 2008). That said, studies of large-scale biofuel production typically define large scale as multi-state or an extensive geographic region such as the U.S. Midwest, but in Hawai‘i it often refers to plantation-style agriculture. For example, because of Hawai‘i's geographic isolation and high inter-island transportation costs, certain economies of scale may not be realized at the same level of production as on the U.S. mainland. In the context of Hawai‘i, the smallholder scale providing for a local market could be a local company generating electricity from biomass for an island or sub-region such as Hāmākua. A smallholder production selling to national or international markets could be a company providing biofuel sourced only from a local area, and a medium- or large-scale commercial production would provide biofuel to the national or international market and feature a dispersed supply chain.

Social benefits need not come at the expense of the environment. Depending on the type and scale of the operation, and management practices, it is possible to conserve biodiversity and ecosystem services while improving rural livelihoods (Milder, McNeely, Shames & Scherr, 2008). Several examples of bioenergy systems around the world combine social and environmental benefits; most of them are at a small scale, although there are proposals in the U.S. to use diverse grasslands for ethanol so as to restore prairie ecosystems.

Therefore the scale of biofuel production in Hawai‘i matters, though little is known about the measureable effects biofuels will have because many variables affect the outcome. Additionally, the ability for a plantation-scale production of biofuels places considerable power in the hands of concentrated, few landowners with the capabilities for such a large-scale type of production. Thus, the distribution of the benefits and costs of biofuel production are also an issue, and should be addressed by policy.

4. Motivations for Biofuel Production and Use

International and national policies supporting biofuels have three primary objectives: creating a diversified energy portfolio, mitigating climate-change, and fostering rural economic development (OECD, 2008; FAO, 2008). This section describes each of these objectives as they apply to the State of Hawai‘i and to Hawai‘i Island.

4.1 Environmental Benefits of Diversification

Energy Diversification. Biofuels are particularly attractive as a renewable energy source for electricity because biofuels are a firm power source that can be used in place of fossil fuels in existing power plant infrastructure with only modest retrofitting (Thomsen, 2005). In addition, a local biofuel industry–complete with locally grown feedstocks and nearby conversion plants– would diversify Hawai‘i's energy sources. On a national level, expanding beyond fossil fuels means that the U.S. can decrease dependence on adverse foreign governments (Park, Chen, & deLeon, 2009). For Hawai‘i, diversifying the local energy portfolio also means fortifying Hawai‘i's ability to endure natural disasters and to avoid or mitigate electric or transportation energy emergencies (DBEDT, 2008b).

Life-cycle Considerations. Implementing a biofuels program merits life-cycle evaluation, and in fact many companies thinking about biomass-to-energy are planning to optimize their crops by marketing primary and secondary products. Life-cycle assessment of biofuels considers the various stages of production and tackles issues around the environmental and economic costs of making energy from agricultural products. Thinking about life-cycle costs means considering each step along the development and production chain to encourage the most efficient use of all products and wastes. Aspects of production to be considered include:

- Location of feedstock production and conversion plants
- Manufacturing and processing tactics, including which crop is selected, inputs required, and the conversion process
- Transportation of materials from the field to the plant
- End use(s) and distribution method(s)
- Opportunities to use byproducts or reuse products and byproducts, thus creating a closed-loop cycle

- Waste management, including reduction and recycling
- Equipment maintenance to optimize production and efficiency (Puppan, 2002).

Current biofuel projects in Hawai‘i have potential to reduce life-cycle costs. Bioenergy producers may consider constructing close-looped systems of production and consumption as one way to reduce life-cycle costs.

Closed-loop systems. Closed-loop production systems are defined as a production system in which an industrial output recycled to create another product. The use of such systems can reduce or eliminate negative impacts on the environment by using conscientiously chosen inputs and outputs to supply each step in the cycle. The following two sub-sections discuss two methods of implementing a closed-loop system: identifying primary and secondary products to minimize or eliminate waste streams, and intercropping to reduce the need for additional or unnecessary inputs.

Biofuels as Primary and Secondary Products. Although some discussions on local biofuel production center on establishing an industry in which biofuels are the primary product, companies in Hawai‘i are also considering utilizing byproduct of other production processes as biofuel feedstock. Biofuels as a primary product means the feedstock is grown for the principal purpose of creating bioenergy. Once the bioenergy is extracted from the feedstock, the remaining waste products, or byproducts, have a range of marketable purposes (Poteet, 2006). These byproducts can garner additional profit for the producer from waste products, while providing inputs for other processes at a low cost (Thomsen, 2005). For example, some common byproducts of biodiesel production include glycerin, seedcakes, residual biomass, food products, and unidentified chemical compounds. Glycerin is generally used in soap or cosmetics and can be employed in the branding of ‘Hawai‘i made’ products. Seedcake remnants can be used in organic fertilizer, animal feed, or charcoal. Most residual biomass is left in the field as a soil conditioner for future crops. Edible byproducts of biodiesel production can boost the economic viability of the feedstock for growers. Additional byproducts may be produced as large-scale production of oil-bearing plants in the tropics progresses and the science to uncover potential insecticidal, medicinal, or cosmetic compounds expands. These compounds could be beneficial for agricultural and human diseases or cosmetic purposes such as skin conditioners (Poteet, 2006).

Algae, grown as a potential biodiesel feedstock, can also be utilized as part of a closed-loop system to absorb flue gases if located near power plants or refineries. This utilizes a significant proportion of greenhouse gas emissions from combustion exhaust to feed the algae, which in turn produce and emit oxygen via photosynthesis (Stauffer, 2006). Once the algae are converted to liquid fuels, the protein and carbohydrate rich byproduct can be used as a nutritional supplement for animal feed (HR BioPetroleum, 2008). The process is not yet commercially viable though application is undergoing extensive research.

Biofuels as secondary products refers to utilization of byproducts from a value-added product for energy generation. Coupling value-added products with bioenergy byproducts allows a company to reduce waste streams and simultaneously to provide the energy needed to produce the primary product. For example, Hawai‘i has been utilizing byproducts from sugar production for several decades by generating electricity through the direct combustion of sugar cane bagasse. Energy is used to power the sugar mills and excess is sold to the local utility company. Another example of biofuel from a byproduct is the direct combustion of seedcake remnants, from biodiesel feedstock conversion, with coal or other biofuels. Furthermore, this demonstrates how both primary and secondary sources for bioenergy can be manufactured from a single crop. Currently, a local company, Tradewinds Forest Products (see Section 7.3: *Potential Tree Crop Users*), is looking to establish a veneer mill on Hawai‘i Island and plans to use its remnant timber to power its manufacturing process and sell surplus power to HELCO (Tradewinds Forest Products, n.d.).

Intercropping. Intercropping is a strategy whereby growers plant two or more crops simultaneously on the same area of land to maximize productivity (Thomsen, Hauggaard-Nielses, Petersson, Thomsen, & Jensen, n.d.). Successful intercropping means that the crops benefit by being planted in close succession, often meaning that less chemical inputs are required. For example, certain legume species can provide nutrients such as nitrogen, reducing or eliminating the need for fossil fuel based fertilizers or soil conditioners (Thomsen et al., n.d.). Another potential benefit of intercropping is weed suppression, if done in conjunction with crop rotation (Liebman & Dyck, 1993). Intercropping biofuel crops with food crops could also provide an economic boost by providing other saleable goods in tandem with bioenergy producing crops. Moreover, this method of propagating multiple species on single plots encourages diversified agriculture, a defining feature for the Hāmākua region in the “Hāmākua Agriculture Plan” (Hāmākua Community Development Corporation, 2006).

However, petroleum is *the* primary energy source worldwide. Hawai‘i’s dependence on fossil fuels differs from U.S. demands because of its reliance on petroleum for electricity generation; while the rest of the U.S. relies mostly on natural gas or coal. While the systems and tactics discussed in this section can provide environmental benefits, they mostly provide economic incentives to encourage local production of biofuels alongside value-added products, through selling waste products, or reducing inputs through intercropping. A clear and consistent measure on the environmental benefits of growing biofuels is greenhouse gas measurement, which has become the foremost tool for assessing the impacts of biofuels on the environment.

4.2 Greenhouse Gas Emissions (GHG Emissions) Reduction

Production and consumption of energy result in the generation of GHG emissions, which change the global climate. Greenhouse gases (GHGs) commonly found in the atmosphere are CO_2, methane (CH_4), nitrous oxide (N_2O), water vapor (H_2O), ozone (O_3), and chlorofluorocarbons (CFCs). These gases have different warming potentials, so accounting for GHG emissions occurs by converting to carbon dioxide equivalents. This equivalency ratio is relatively high for some biomass specific GHGs: methane has 21 times the global warming potential of carbon dioxide, and nitrous oxide has 310 (von Blottnitz, 2007). The reduction of GHG emissions has emerged as a global concern, and has sparked international agreements and negotiations such as the Kyoto Protocol, Bonn Climate Change Talks, and the upcoming Copenhagen Conference of the United Nations Framework Convention on Climate Change.

Hawai‘i's Net GHG Emissions. In Hawai‘i, 2007, net emissions totaled 21.52 million metric tons (MMT) CO_2 equivalent. Approximately three-fourths were emitted on O‘ahu. Figure 10 reveals the highest emissions originate in the transportation (about 51 percent) and electric energy (about 36 percent) sectors, making up nearly 90 percent of emissions (ICF International, 2008). The waste sector emits approximately 4 percent and agricultural and forestry sectors emit just over 3 percent of the GHGs in Hawai‘i (ICF International, 2008). Residential and commercial contribute about 1 percent, while industrial processes and energy sectors produce 2 percent and 0.7 percent respectively (ICF International, 2008).

In 2007 total emissions of most sectors were 5 percent higher than in 1990, the common baseline year used to measure GHG emissions. Technological advances in aviation accounted for a reduction in airline transportation related GHG emissions. The ground and water transportation sectors and energy sectors saw a considerable rise in emissions, about one-fifth in each sector (ICF International, 2008).

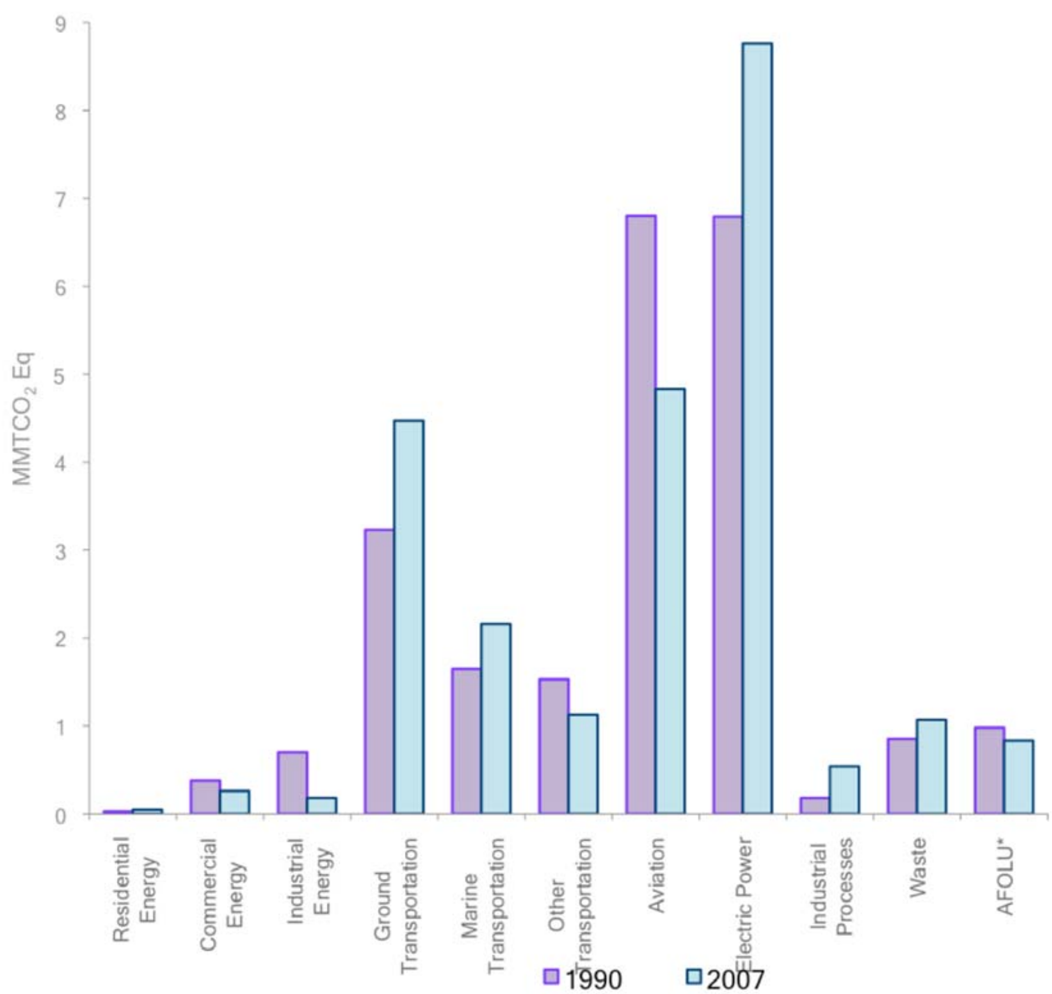


***Figure 10**. GHG emissions in Hawai‘i,1990 & 2007.* Data adapted from the *Hawai‘i Greenhouse Gas Inventory: 1990 and 2007* (ICF International, 2008).
*"AFOLU" refers to Agriculture, Forestry, and Other Land Uses sources. If one includes sinks (e.g., trees or soil)

in the calculation for this sector, the net sequestrations are negative and show slight improvements in sequestration between 1990 and 2007, -2.67 to -2.75 respectively.

Policy Action. The Hawai'i State Legislature acknowledges that GHG emissions and the associated potential climate change pose a threat to Hawai'i. Act 234 (State of Hawai'i, 2007) addresses the need to reduce GHG emissions in Hawai'i. It mandates the reduction of GHG emissions to levels at or below 1990 emissions by the year 2020. This act also created a task force to conduct a GHG inventory and develop the work plan for emissions reduction for the State by the 2010 legislative session. At the national level, recent legislation as proposed by Representative Henry Waxman, entitled The American Clean Energy and Security Act of 2009, has moved through Congress and is now in the hands of the Senate. The question of how to synthesize state and future federal efforts is yet to be determined.

Controversy over Calculating GHG Emissions. Biofuels have the potential to reduce GHG emissions, in that the biofuels replace a quantified amount of fossil fuels that would have emitted a certain amount of GHG emissions in its combustion. The "avoided emissions" are therefore considered a reduction in GHG emissions (von Blottnitz, 2007). However, accounting for the GHG emissions depends on various factors in the energy system and a standard methodology is still under development (Schlamadinger et al., 1997; Johnson, 2009). For example, considering only the production of biomass and its conversion to biofuels neglects to include the GHG emissions associated with the production of the inputs for biomass production, and the energy embodied in the facilities and equipment used. It also ignores the GHG emissions caused by the shift in end-use practices or equipment that must occur because of the change in fuel source (Schlamadinger et al., 1997). This type of GHG emissions analysis is often coupled with a life-cycle assessment of the product, which includes its impacts to the environment and human health. Because it is difficult to discern the GHG emissions indirectly associated with biofuels as the system boundaries expand, the information about GHG accounting discussed in this section is based solely on the production of the biomass and its conversion to biofuel. Whether biomass production is carbon neutral is still under investigation (von Blottnitz & Curran, 2007). Conflicting methodologies have resulted in strong arguments for both sides (Shapouri, Duffield, & Wang, 2002; Hill, Nelson, Tilman, Polasky, & Tiffany, 2006; Pimentel, 1991; Johnson, 2009).

Impact of Agricultural Practices on GHG Emissions. Fluctuation in CO_2, N_2O, and CH_4 are all associated with crop production and land use conversions from natural ecosystems to agriculture. GHG reductions vary with respect to land use prior to agricultural production. This is because the carbon storage mechanisms of various ecosystems vary depending on the biomass of the ecosystem and the storage ability of the soils, among other factors (Adler, Del Grosso, & Parton, 2007). The amount of these GHGs released during agricultural production is dependent on the agricultural inputs used, which in turn depends on site and crop-specific characteristics. The efficiency of the reduction amount of GHG emissions is dependent upon the yield of the feedstock crop, which is again dependent upon the inputs applied, and site specificity (Adler et al., 2007; Kaltshnmitt, Reinhardt, & Stelzer, 1997). Practices that reduce the amount of GHG emissions can include low or no-till cultivation, crop rotations, properly-timed fertilizer application, among many others.

Examples of Potential Impact of Biofuels on GHG Emissions. Ethanol is seen as a moderate to strong substitute for gasoline. Current ethanol production from corn in the U.S. results in a 12 percent reduction of GHG emissions compared to fossil fuels they displace (Hill et al., 2006). Biodiesel from soy results in a 40 percent reduction (Hill et al., 2006). The most land-efficient crops for the production of bio-ethanol are sugar crops, as opposed to starch crops, specifically tropical sugar cane (von Blottnitz & Curran, 2007). In addition, crop residues may be seen as an efficient feedstock with the development of more efficient conversion processes. Biodiesel produced from soybeans on the continental U.S. has also been proven to be advantageous with respect to GHG emissions. Soybean biodiesel has advantages in GHG emissions reductions over bio-ethanol because it requires less agricultural inputs and currently undergoes a more efficient conversion process (Hill et al., 2006).

It is outside the scope of this study to assess the net energy and GHG emissions related to biofuels in Hawai‘i. However, this is an important consideration in whether to pursue biofuel production and thus should be investigated.

4.3 Rural Economic Development

Rural communities, particularly agricultural ones in Hawai‘i and in other regions, are under tremendous economic and social pressure. Across the U.S., such communities are losing traditional job bases, such as farming or low-wage manufacturing, as well as traditional cultural and natural resources. As a result, many of these communities are transforming themselves into tourism or retirement destinations (Brown-Graham, 2007). One strategy to preserve the character, traditions, and land use of rural communities is developing a local bioenergy industry (FAO, 2008).

Biofuel production on rural agricultural land has the potential to revitalize land use and livelihoods in rural areas (Cotula, Dyer, & Vermenulen, 2008). Since much of the land in Hāmākua is primarily classified as agricultural, according to State land use zoning, a local biofuel industry could offer many economic benefits. The agriculture sector's increasing role as a feedstock provider for biofuel production creates higher demand for farmers' products. A stronger link between agriculture and energy demand could result in higher agricultural prices and output (FAO, 2008).

Employment in Hawai‘i's Agricultural Industry. In 2007, Hawai‘i's total farm workforce was estimated at 6,500, less than 1.8 percent of Hawai‘i's labor force. The combined average wage for field and livestock workers was estimated at $12.84 per hour (NASS, 2007; DBEDT, 2007d). Table 3 displays average salaries by agricultural sectors in Hawai‘i. The potential for a local biofuel industry carries the potential for more employment opportunities in agriculture and related fields.

Table 3
Existing agricultural salaries

Sector	Average salaries by sector, Statewide[1/]
Sugarcane	$45,470
Vegetables	$25,732
Macadamia nuts, coffee, and other fruits	$28,455
Pineapples	$37,501
Flowers and nursery products	$24,099
Other crops	$36,917
Animal production	$33,287

[1/]From the 2005 State Input-Output Table

Biofuels Employment. Job creation is one of the expected impacts of biofuel production, since a biofuel industry requires employees to work at the agriculture, processing, and distribution stages. As a forest product, however, harvesting is likely to be highly mechanized and thus offers minimal employment. Direct employment includes jobs in "crop production, construction, operation and maintenance of conversion plant and for transporting biomass" and indirect employment means jobs "generated...as a result of expenditures...from all activities connected, but not directly related, like supporting industries, services and similar" (Domac, Richards, & Risovic, 2005, p. 102).

Employment within the bioenergy industry varies with feedstock selection, conversion processes, location, and degree and type of mechanization. While disagreement exists over best methods for economic modeling and specific outcomes, examples where a biofuels industry has or is predicted to increase employment include in the U.S. Midwest and South (Leistritz & Hodur, 2008; Gan & Smith, 2007; Parcell & Westhoff, 2006; Petersan, 2002; Swenson, 2005; Flanders, Luke-Morgan, Shumaker, & McKissick, 2007; Mayfield, Foster, Smith, Gan, & Fox, 2007). At the same time, rural communities can preserve their lifestyle by maintaining open space and industry (Gan & Smith, 2007; Cotula et al., 2008).

5. Tradeoffs Associated with Biofuel Production and Use

Despite the benefits discussed in Section 4, biofuel production and consumption is accompanied by significant environmental and social concerns. These concerns include potential competition between food and fuel crop production, environmental concerns related to agricultural production, and the concerns surrounding conversion processes and end uses.

5.1 Food Production and Biofuels

The Global Situation. Since the agricultural production of bioenergy is linked intrinsically to growing food, biofuel feedstock production is affecting global agricultural markets and has prompted a worldwide “food versus fuel” debate (FAO, 2008). Expanding biofuel production could increase the prices of both biofuel feedstock and competing crops, with implications for land allocations, food prices, and the environment (Elobeid, 2007).

Expanding biofuel production in the quest for energy diversification will increase the demand for farm products, but may also raise the price of food and generate competition for natural resources such as land and water. Higher prices on agricultural commodities, while a boon for farmers, threaten food security, particularly for the most at-risk communities in developing countries (Prabhu et al., 2008; FAO, 2008). The Food and Agriculture Organization of the United Nations (FAO) describes four dimensions of food security: food availability, stability of food supplies, access, and utilization—people’s ability to absorb nutrients (FAO, 2008). Food availability is the dimension that is most relevant to a food versus fuel debate in Hawai‘i.

Some experts argue that higher energy prices are creating price floors for agricultural commodities when the demand from the energy sector is large and biofuel feedstocks are competitive in the energy market. Price ceilings are also driven by the rate at which biofuel feedstock prices rise relative to energy prices and among feedstock types (Elobeid, 2007). When biofuel demand bids up the prices of commodities used as biofuel feedstock, it tends to bid up the prices of all agricultural commodities that rely on the same resource base (FAO, 2008). For this reason, producing biofuels from non-food crops will not necessarily eliminate the competition between food and fuel (FAO, 2008).

The degree to which biofuel demand has influenced recent food and commodity trends is a matter of debate—estimates range from 3 to 30 percent (USDA, 2008; IFPRI, 2008). However, when coupled with the impacts of climate change (drought and other severe weather patterns, changes in growing seasons, increase in pests), it is undoubtedly an issue warranting discussion.

The Local Situation. With 1,121,329 acres of farmlands in production in Hawai‘i and 170,727 acres of land not in production (NASS, 2007), it is unclear whether biofuel production will compete with food production in Hāmākua. Competition for land becomes a particularly pressing issue when crops that are currently cultivated for food and feed are redirected toward the production of biofuels, or when food-oriented agricultural land is converted to biofuel production (FAO, 2008).

Even though a competition between food and agriculture is not yet apparent in Hawai‘i, the recent “place-based branding strategy” may indicate some preference in sustaining local agricultural food production. Much of the land currently in agricultural production in Hawai‘i is devoted to diversified agriculture. In practice, diversified agriculture in Hawai‘i has come to mean niche markets—products that are merchandised as exclusive to Hawai‘i through the place-based branding strategy. The long-term strategy to brand specific foods, like pineapple and macadamia nut, to a Hawaiian vacation experience has created the opportunity for farmers to think creatively about their crops and marketing strategies (Suryanata, 2000). The number of individual farms increased by 23 percent between 1990 and 2006; but at the same time, Hawai'i has fallen away from producing commodities for local consumption, as was done historically, in favor of these more lucrative agricultural products (DBEDT, 2007d).

The first two major diversified agricultural products in Hawai'i were pineapple and macadamia nut. Over 100 years of marketing efforts made pineapple iconic to Hawai'i. However, its increasing popularity on the global market in the mid-20th century turned out to be detrimental to the local industry – Hawai'i pineapples became less competitive as production expanded worldwide, and the market declined rapidly until Del Monte closed its O'ahu plantation in 2006. The macadamia nut market has experienced great change since commercial production began in 1949. Hawai'i had risen to the top of the market in the 1980s, but escalating land prices and expanding global production caused Hawai'i's share of the macadamia nut market to fall from 89 percent in 1987 to 36 percent by 1997 (Suryanata, 2000).

The rise and fall of pineapple and the struggling macadamia nut market demonstrate that an agricultural sector that depends so strongly on a few niche products is bound to fall victim to global market expansion and consumers will opt for the more available, cheaper version of an iconic product. Another issue with place-based branding strategies is that the agricultural sector is not allowed to move past the "inventive" stage, and as a result, producers are continually looking for new, more exotic products and new ways to brand established crops. The recent "made in Hawai'i" movement, which encourages local residents to consume local produce, seems to be more resilient. It retreats from the symbols constructed by the tourism industry to favor Hawai'i's natural environment and social relationships (Suryanata, 2000).

Hawai'i Island has a selection of successful niche crops including coffee and macadamia nuts for export. This is an economic success for respective farmers but these agricultural products are not necessarily producing a well-rounded diet for the community. As a state, Hawai'i imports 90 percent of its beef, 65 percent of fresh fruit, and nearly 70 percent of its fresh vegetables (Office of the Governor, 2008). Local dairies, 25 years ago, were able to fulfill the islands' complete dairy needs but now only supply 30 percent of the market as local producers close their businesses (Office of the Governor, 2008). A new agriculture-based biofuel industry on Hawai'i Island has the potential to compete with the production of these products since all depend on the same land and other natural resources.

5.2 Environmental Concerns Regarding Agricultural Production

Currently, Hawai'i has 7,521 farms on over 1.1 million acres statewide. Since the vast majority of this land is currently in diversified agriculture, activity on these acres does not make a large contribution to local energy production (DBEDT, 2007d). However, as large tracts of lands are considered for biofuel production, it is important to examine the potential environmental impacts of expanding agricultural production in Hawai'i. This section examines the negative environmental impacts associated with inputs used in production, changes in land use practices and land conversion, monocropping, and tillage practices. Water allocation and water policy are also discussed because of the potential expansion of irrigated agriculture. Finally, issues regarding the affect of the cultivation of invasive species and genetically modified organisms on the surrounding ecosystem are addressed. The applicability of many of these impacts depends upon the management decisions of the agricultural producers, and thus the degree of environmental impact is relative to the use of best management practices and site selection. Addressing these issues and ameliorating the negative impacts caused by biofuel production and use is a necessary part of the successful integration of biofuels into Hawai‘i’s energy system.

5.2.1 Environmental Impacts Related to the Agricultural Production of Biocrops

Agriculture, like all other production, requires inputs. These inputs have the potential of escaping from areas of agricultural production to affect surrounding areas. Pollution from agricultural production differs from pollution from manufacturing facilities because the agricultural environment is not a closed system. Inputs used in agricultural production can modify nearby ecosystems and human health. Specifically, fertilizers, pesticides, and herbicides can be transported off the farm.

Fertilizers can be made from inorganic or organic sources containing some combination of phosphorus, nitrogen, and potassium. Inorganic fertilizers require large amounts of energy for production while organic fertilizers often require mining of deposits, both of which have environmental side effects. The production of inorganic chemical (mineral) fertilizers consumes natural gas or petroleum, as these fertilizers require a source of hydrogen (Miranowski, 2005). The amount of fertilizer needed is highly crop and soil specific, and the application of the fertilizers depends on the crop and environment.

Like many crop inputs, pesticides and herbicides are also site and crop dependent. Historically, pesticides containing arsenic were used in sugar cane fields with detrimental environmental and health impacts. Before extensive regulation was developed for the use of pesticides, the chemicals used would leach into the soil and groundwater, leaving residues that could be found as far as 15 meters deep (Alavi, Dusek, Vogel, Green, & Ray, 2007).

The chemicals associated with fertilizers, herbicides, and pesticides can leave the farm through leaching, volatilization, agricultural runoff, and erosion into nearby ecosystems and waterways. Leaching occurs when water flows through the soil, dissolving chemicals from the soil and transporting them with the flow of the ground water; chemicals can eventually enter the water table or flow into rivers, streams, or springs, leading to the ocean. Volatilization takes place when the inputs chemically react with the atmosphere, sunlight, water, or other compounds in the soil and become airborne which allows for potential natural transport of these chemicals away from the site of their application. Runoff happens when the land receives more water than it can absorb. The runoff that leaves agricultural lands can carry dissolved chemicals and soil, which allows these input chemicals to gain mobilization through the hydrological systems (Whitford et al., 2001).

The transfer of agricultural chemicals from the field to nearby ecosystems can cause deleterious effects on human health and the health of ecosystems. The leaching of chemicals into groundwater supplies contaminates drinking water, which can affect human health, and can eventually alter the chemistry of natural waterways. Volatilization of agricultural chemicals can lead to changes in the pH of soils and precipitation via a process called acidification, described in section 4.3. Runoff and erosion of fertilizers can lead to eutrophication—the fertilization of a water body causing increased biomass growth and decay, often resulting in oxygen-poor conditions (Hill et al, 2006). For Hawai‘i, the near-shore ocean is sensitive to agricultural runoff because of the addition of nutrients and sediment. Specifically, the delicate balance of nutrients and sunlight in coral reef ecosystems is sensitive to addition of these inputs.

Runoff and leaching from the application of fertilizers can be controlled to some extent through tillage methods and application methods. Low tillage reduces fertilizer runoff, and proper application timing and methods improves the absorption and utilization of the fertilizer. Also, careful calculations of adequate amounts of chemicals can reduce the excess available for transport away from the land (Miranowski, 2005). Many of these management practices are site specific and thus require an analysis of the site and crop. The Hawai‘i Department of Agriculture (HDOA) limits the type and amount of pesticides that can be used by growers in an effort to promote more sustainable pest control (HDOA, 2007a). Pesticides with high leaching potential are heavily regulated (Alavi et al., 2007). Manual, sustainable efforts for pest control have been experimented with in Hawai‘i (Schenck, 2003). Also, sustainable pesticides in the form of biological control agents, and crop rotations can be used.

5.2.2 Land Use Practices and Land Conversion

An increase in agriculture onto land that is currently not in production involves changes in the land use, which can also affect the environment. Effects would be greater with large-scale monocrop plantations. Economies of scale are a motivation for large-scale monocropping and production. In addition, initiating agricultural production on fallow or underutilized land can disrupt the previous ecosystem and displace species that may have migrated to the area. Certain plant and animal species will need to be cleared off fallow or underutilized lands prior to the start of agricultural production. While this concern does not apply to the destruction of native critical habitats, which are legally protected, changes in land use can increase GHG emissions by reducing the amount of carbon stored in the soil and biomass of the area. This can also destabilize the soil (US EPA, 2006).

Another possible concern for biofuels is the use of marginal lands for biofuel production and the desire to keep prime agricultural land available for food production. Since marginal lands are less productive than prime agricultural lands, the use of these lands can perhaps become an issue as the risks and costs are higher to smaller yields. Marginal lands usually have poorer quality soils and less precipitation than prime agricultural lands. They can also be difficult to harvest because of steep slopes or varied terrain, compared to better agricultural land. Regardless of these potential difficulties, biomass crop production can be a candidate for marginal land use. This is due to the type of biofuel being produced and the conversion mechanisms chosen—crops are often drought tolerant, require fewer inputs, and are able to grow in sub-optimal soil conditions such as variability in pH and soil salinity (FAO, 2008).

In undisturbed ecosystems, the amount of carbon stored in the soil reaches equilibrium as additions of organic material is in balance with the losses. Organic matter is important for plants because it contains vital nutrients. Intense agriculture reduces soil organic matter because nutrients are removed from the soil for the production of a crop, which, for most biomass production, is then harvested and removed from the land. Therefore, a high amount of organic matter is removed from the site when producing a biomass feedstock. Since the decomposition of plant tissue significantly contributes to soil organic matter and nutrients, the constant removal of biomass that would have remained to decompose will decrease the amount of organic matter stored in the soil (Cowie, Smith, & Johnson, 2006). Cowie et al. (2006) state that land use conversion from conventional grain or timber production to bioenergy crops reduces organic matter input, causes nutrient deficiency, and directly impacts plant productivity. In order to restore the health of the soil, the addition of fertilizers or the planting of a cover crop is necessary. The use of perennial plants as a biofuel feedstock can also reduce the stress on the soils (FAO, 2008).

In addition to altered soil quality, land use decisions and management practices can also lead to decreases in the amount of fertile topsoil. Agricultural production can lead to erosion by leaving the soil exposed to the effects of ample watering or precipitation. This has significant negative effects on the environment. The loss of productive layers of topsoil increases the costs of fertilization necessary for productive agricultural lands. The removal of this topsoil also contributes to eutrophication, as mentioned in 5.2.1, because the fertile soil contains nutrients. Erosion also introduces particulate matter to natural waterways, reducing the amount of light able to penetrate into the water, affecting aquatic ecosystems. The amount of erosion is generally site specific and primarily related to ground cover, slope, and rainfall.

Monocropping Concerns. Monocropping refers to the annual growing of the same crop on the same land with little to no crop rotation, typically done on a large-scale plantation-style farm. Economically, monocropping is attractive because it allows agricultural producers to take advantage of economies of scale and specialization in crops, labor, and equipment. However, monocropping can cause environmental and ecological damage (GEG, n.d).

In Hawai‘i, a study on the emergence of kava monocropping in Hawai‘i in the late 1990s and early 2000s by the University of Hawai‘i’s College of Tropical Agriculture and Human Resources highlighted some of the negative impacts of monocropping in Hawai‘i. The study found that monocropping kava was good if the goal was the highest yields possible per unit land area but was accompanied by a multitude of negative environmental and ecological related issues. These included a number of severe plant disease problems, a high pest risk, high inputs and costs, soil degradation, decreased biodiversity, and the likeliness of erosion and reef sedimentation (Nelson, n.d.).

The effects of monoculture can be ameliorated by proper land and crop management. Though monocropping concerns are valid and should be addressed, biofuel production does not require monoculture—several species of biomass producing crops can be planted together. There is also the possibility of silvopasture (discussed in Section 7), crop rotation, and other crop production mechanisms.

5.2.3 Water Allocation

Depending on the species, site characteristics such as acreage and precipitation, and desired yields, different amounts of irrigation water may be needed for growing biofuel crops. Typically, crops for first generation biofuels, such as sugar cane, require more water than feedstocks for cellulosic conversion technologies. Other crops, such as the existing eucalyptus trees in Hāmākua, are rain fed, thus not requiring water diversion. Irrigation water for agriculture often comes from water sources that are diverted from other areas. The diversion of water is often a contentious subject because instream water can have a cultural or ecological purpose and diverting the water for agriculture places a value judgment on water use.

The lack of a state-wide comprehensive agricultural water use and development plan has been a challenge to planning for biofuel production in Hawai‘i (El-Kadi, Evensen, Fares, & Ogoshi, 2009). There are at least two relevant aspects to Hawai‘i's water policy. First, Hawai‘i has a history of extensive irrigation systems from the plantation era; and, for the purpose of diversified agriculture, the State has planned to restore former sugar irrigation infrastructure. However, the second aspect is that State water policies (and significant court rulings that interpret these policies) recognize the many uses of both instream and ground water, including environmental services. These two goals are potentially contradictory. Data are currently being gathered to inventory and monitor water in the State and to facilitate the implementation of water plans (Water Resource Protection Plan, 2008).

The closure of the sugar plantations in the 1990s meant plantation irrigation systems were abandoned and left to deteriorate. Subsequently, the State initiated plans for the future use of those systems and lands. Citing the importance of agriculture to the State of Hawai‘i, the State Legislature conceived the Agricultural Water Use and Development Plan (AWUDP) to "ensure that the plantation irrigation systems affected by plantation closures would be rehabilitated and maintained for future agricultural use" (Water Resource Associates, 2004, p. xi). In 1998, the Legislature enacted Act 101 to (1) authorize the Hawai‘i Department of Agriculture (HDOA) to study and rehabilitate plantation irrigation systems in the AWUDP and (2) provide authority for the AWUDP to become part of the Hawai‘i Water Plan on par with municipal water use and development plans.

The AWUDP proposed transforming former plantation systems to diversified agriculture use, which was touted as a realistic means for achieving food self-sufficiency while supporting agriculture as one of the State's most important industries. Diversified agriculture would take advantage of Hawai‘i's climate, soils, 12-month growing period, and existing former sugar irrigation systems (Water Resource Associates, 2004, p. 13).

The main goal of the plan was to replace much of the State's imported produce with locally grown produce. However, the same factors that were identified by the AWUDP (2004) as ideal for diversified agriculture have more recently been considered conducive to biofuel production. Biofuels have been identified as a potential catalyst for increased agricultural production and development in the state (NREM, 2008). The Lower Hāmākua Ditch system, specifically, has been identified as having the greatest potential for biofuel production, based on land and water availability (NREM, 2008).

Though preserving the use of irrigation water is important for agriculture in the State, it is not without controversy since the diversion of water for agriculture affects instream flow. Hawai‘i's streams have extreme variations in flow, largely dependent upon rainfall in the watershed. Additionally, streambeds are fed by groundwater and variations in groundwater can affect the stream (Wilcox, 1998). The ecological health of streams relates to the amount of water in the stream. Traditional downstream uses require specified amounts of instream flow, making water diversion a potential problem, especially during low flow periods. The diversion of water for agriculture and development, therefore, can become an issue, as evidenced by the Waiahole ditch diversion, an ongoing issue on O‘ahu (Earth Justice, 2006). Though such issues are not common for all stream diversions, the scarcity of water and the potential expansion of both population centers and agricultural production can lead to an increase in water demand.

5.2.4 Crop Choice and GMO Concerns

Risk of Invasiveness. In a recent study through the University of Hawai‘i at Mānoa Pacific Cooperative Studies Unit, researchers used a weed risk assessment system (WRA) to determine the potential invasiveness of 40 biofuel crops proposed for use in Hawai‘i. Table 4 shows the results for the biofuel feedstock species listed in Section 2. All species are currently present in Hawai‘i. Kukui, oil palm, and jatropha are potential biodiesel feedstocks, while all eucalyptus species are potential biomass feedstocks and leucaena, guinea grass, napier/banagrass and sugar cane are potential ethanol feedstocks (Buddenhagen, Chimera & Clifford, 2009).

Through WRA screenings, the majority of these potential biofuel feedstock species were categorized as naturalized in Hawai‘i. The only exceptions were oil palm, *Eucalyptus grandis*, *Eucalyptus urophylla*, and sugar cane (Buddenhagen et al., 2009). Naturalized species have been introduced to an area and exist in the wild. A naturalized species may be considered invasive should its population become abundant enough to have an adverse effect on native ecosystems (Raven et al., 2004). Several species were found to be invasive in Hawai‘i, including kukui, *Eucalyptus globulus*, leucaena, guinea grass and napier/banagrass. These same species were also found to be invasive in other climatically similar regions, along with jatropha and *Eucalyptus grandis*. Finally, researchers evaluated the risk of expansion for each species. According to the WRA, only *Eucalyptus robusta* and sugar cane are not at high risk for expanding substantially beyond the species’ current range (Buddenhagen et al., 2009).

Table 4
Selected biofuel feedstock species with associated status and risk categories

	Naturalized	Invasive in Hawai‘i	Invasive Elsewhere	Risk of Expansion
Kukui (*Aleutrites moluccana*)	X	x	X	High
Oil palm (*Elaeis guineensis*)				High
Jatropha (*Jatropha curcas*)	X		X	High
Eucalyptus globulus	X	x	X	High
Eucalyptus grandis			X	High
Eucalyptus robusta	X			Low
Eucalyptus saligna	X			High
Eucalyptus urophylla				Evaluate
Leucaena (*Leucaena leucocephala*)	X	x	X	High
Guinea grass (*Panicum maximum*)	X	x	X	High
Napier/banagrass (*Pennistum purpureum*)	X	x	X	High
Sugar cane (*Saccharum officianrum*)				Low

Note: Associated naturalization and invasive status and risk category. Adapted from Buddenhagen et al. (2009).

These findings are not surprising, considering that these potential biofuel feedstock species were chosen because each is highly adaptable to a subtropical climate. However, some of the species found to be invasive elsewhere spread only in particular locations or with the aid of specific pollinators. For others, expansion may be slow enough to control. The researchers in this study suggest that producers be required to fund or conduct invasive species control (Buddenhagen et al., 2009).

Genetically Modified Organisms. Another concern about biofuel production in Hawai‘i is the potential use of genetically modified organisms (GMO). Genetic modification, or genetic engineering, describes the transfer of specific genes between organisms using recombinant DNA technology—instead of cross-breeding in the field, segments of DNA that code for specific characteristics are artificially selected and transferred into a new GMO crop. Similarly, genes that code for undesired characteristics can be removed (Wieczorek, 2003). Genetic modification allows for the development of more desirable crop traits much faster than through traditional cross-breeding. This can enable greater improvements in food and biofuel crop production. However, GMO crop production is also accompanied by concerns about the environmental and social impacts, such as resistant weeds and loss of biodiversity.

Much of the hesitation against GMO technology in agriculture is rooted in a fear of gene transference of transgenetic DNA from GMO crops into wild species or into similar non-GMO crops growing in nearby fields. Should transgenetic DNA transfer into wild species, some opponents of GMO crops worry that herbicide resistant genes will be found in weeds, making them difficult to control and creating ecological imbalances that negatively impact biodiversity. However, most of GMO crops in the United States do not have closely related wild relatives and precautions can be taken to avoid opportunities for gene transference. For instance, providing space and staggering pollination times can avoid transference. If gene transference to wild species does occur, it is likely that the weeds can still be controlled with other herbicides or by other means (Snow, Ando, Gepts, Hallerman, Power, Tiedje, & Wolfenbarger, 2004).

Some opponents to GMO crops are also concerned that further negative impacts on biodiversity may occur if GMO crops are successful. Restrictions on GMO technologies enable biotechnology companies to protect the GMO variety or breed from unauthorized use. The use of 'terminator technology' can have different impacts on farmers and breeders. The success of GMO crops could result in large areas of land being planted with a single crop variety that shares the same susceptibility to disease or environmental change (Visser, van der Meer, Louwaars, Beekwilder, & Eato, 2001).

GMO companies are already conducting research in Hawaiʻi. Among these companies, Ag Innovations (2009) on Hawaiʻi Island is looking into genetically modifying oil crops, such as jatropha and oil palm, for biofuel use. The use of GMO crops by these companies present the tradeoff with using GMO crops in biofuel production; GMO crops can produce higher yields with lower input costs, but may negatively impact biodiversity.

5.3 Impacts of Conversion of Biomass to Biofuels and Biofuel End Use

Though many biofuel conversion technologies are still in the developmental phases, and many of the impacts of the end uses of biofuels are yet to be determined, there are outcomes associated with current conversion mechanisms and end uses that cause concern for biofuel production in Hawaiʻi and elsewhere. The conversion concerns are centered around particulate matter emission and environmental pollution. The use of biofuels in our current infrastructure requires modifications in our current modes of transportation fuel distribution and electricity generation. Experience with the 10 percent ethanol blending mandate has made end-use sectors aware of some of these concerns.

5.3.1 Conversion

Local air quality can be impacted by the industrial processes that occur at the conversion plants. This can result in higher carbon monoxide levels, particulates, nitrogen oxide, sulphates, and volatile organic compounds (FAO, 2008). The emission of sulfur and nitrogen oxides into the atmosphere can cause acidification. The conversion of biofuels causes the release of some of these chemicals (mostly nitrogen oxides), which are naturally found in the soil and organic matter. The acidification occurs when these particles mix with atmospheric gases and water creating sulfuric and nitric acids. The acid is then deposited through precipitation, lowering the pH of the soil. Acidification also occurs during the refining and combustion of fossil fuels because similar particles are released and often fossil fuels release more harmful particulates than biofuels (El Bassam, 1998). These particles are also associated with particulate matter that can cause respiratory illnesses (Weiss, Patel, Heilmeier, & Bringezu, 2007).

Biodiesel and ethanol production also results in wastewater that contains organic materials. This water requires treatment before being released to prevent eutrophication (FAO, 2008). If left untreated, eutrophication can be detrimental to aqueous environments, as mentioned in Section 5.2.1.

5.3.2 Distribution and End-Use

The use of biofuels for end-uses such as electricity and transportation requires some modification of existing distribution and end-use mechanisms. For electricity, the changes that need to occur at the plant level include retrofitting of existing generators to run on biofuels, or the construction of new generators to be compatible with biofuel use. The distribution of generated electricity can be done via the existing, albeit antiquated, grid system. Biofuel transportation fuel, however, requires significant adaptations.

Ethanol is the predominant biofuel used for transportation in the world (EIA, 2007). Typical blended fuels include E10, a 10 percent ethanol in gasoline blend, and E85, which is currently averaging 74 percent ethanol in gasoline. B2, B5, and B20—the numbers represent the percent biodiesel in the blend—are the typical biodiesel blends found in the U.S. (EIA, 2007).

Ethanol contains less energy per unit volume than conventional gasoline; similarly, biodiesel contains less energy than conventional diesel (distillate fuel oil). This comparative decrease in energy content of transportation fuel causes a decrease in the number of miles per gallon obtained through the use of these biofuels. The decrease in fuel economy is directly related to the amount of biofuels blended in the fuel mixture: E10 fuel has a 3.3 percent reduction and E85 fuel has 24.7 percent reduction in energy content per gallon of conventional gasoline. Another way of portraying this difference in energy content would be to compare the amount of fuel needed: 1.03 gallons of E10 fuel, and 1.33 gallons of E85 fuel is needed for a vehicle to travel the same number of miles as 1 gallon of conventional gasoline. For biodiesel, 1.08 gallons is needed for a vehicle to travel the same number of miles as 1 gallon of diesel fuel (EIA, 2007). The development of a system supportive of electric vehicles is one way of avoiding this loss of energy, by using biomass to produce electricity, which in turn is used in transportation.

Distribution of the biofuel itself and higher blends of biofuels (E85 and B20) is difficult because most existing storage, transport, and dispensing equipment need to be made with biofuel compatible materials. Commercial gas stations require costly retrofitting which adds to the consumer cost of the biofuel (EIA, 2007).

The availability of consumer (light-duty) vehicles that run on the higher blends of biofuels (B20 and E85) is low. The expansion of biofuels as a transportation fuel above the E10 and B5 levels requires an increase in the production and awareness of flex-fuel vehicles, of which only 5 million were made in the period between 1992 and 2007 (EIA, 2007). In 2006, about 2 percent of Hawai‘i’s vehicles were E85 flex-fuel vehicles, 12 percent less than necessary to meet the states alternative fuel standard by 2020 (Rocky Mountain Institute, 2006). Hawai‘i also has no stations that supply the E85 fuel (EERE, 2009a).

The 10 percent ethanol blending mandate passed by the Hawai‘i State Legislature has resulted in end-use concerns for certain industries. Act 130 of 2007 called for a report regarding the distribution and availability of non-ethanol gasoline. This report mentions the need for non-ethanol blended gasoline in niche markets, including “certain boats, small gasoline-driven tools, and experimental and light-sport aircraft” (DBEDT, 2007c, p. 1). The use of fiberglass and incompatible fuel parts have resulted in the breakdown of old engines and storage tanks, when exposed to ethanol blended gasoline. Issues with aircraft that use automotive fuels have also arisen because of certification and compatibility issues (DBEDT, 2007c). Classic cars may also experience difficulty when using ethanol blended fuels because of the octane rating, change in fuel volatility, and materials compatibility, though the latter is usually resolved by regular car maintenance requiring the replacement of old parts with age (Downstream Alternatives, Inc., 1996).

PART III: Hāmākua Case Study

Biofuels provide an opportunity to reduce Hawai‘i's dependence on imported fuel sources. Given its land availability and agricultural background, Hāmākua has been identified as a potential site for biofuel production. A biofuel industry could prompt rural economic development and greener energy production; however, aspects of their production have faced community opposition. This is due to the lack of transparent decision-making process and potential negative outcomes relating to competition between land uses and other environmental impacts. This part of the report provides an overview of the Hāmākua region, and the existing eucalyptus trees. Through interviews with experts and stakeholders, several viewpoints and attitudes on the appeal and prospective suitability of biofuels were documented.

6. An Introduction to Hāmākua: History, Land, and People

6.1 Hāmākua: A History of Sugar

Hāmākua, located on the northeastern end of Hawai‘i Island, is one of the island’s six *moku* (traditional districts). Hawai‘i’s commercial sugar industry started in 1835. It suffered many ups and downs over the years, with trade negotiations and tariffs being the most onerous challenges to profitability prior to statehood (La Croix, 2002; Wilcox, 1998). Hāmākua Sugar Company closed in 1993, and the last sugar plantation on Hawai‘i Island closed in 1996. In addition to providing jobs for laborers, the sugar industry supported research into genetically modified crops, fertilizers, and application and harvesting practices in order to develop increased efficiency and yield in sugar cane harvests (Nishimoto, 2004).

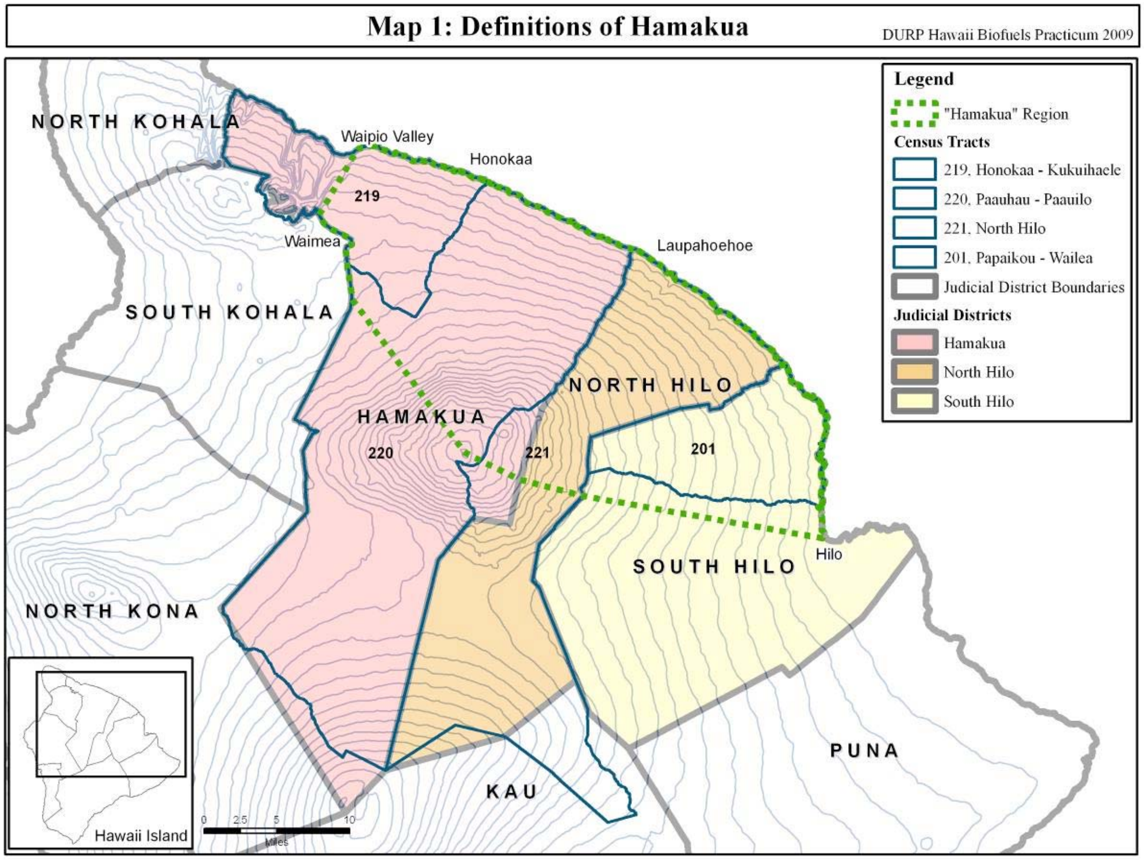
The community of Hāmākua grew around the physical plantation, which partly explains the current pattern of land use. The economic model of the sugar era led to the development of plantation towns, since having the plantation provide services, housing, and goods clustered close together was more cost-effective and beneficial for workers and their families (Beechert, 1985, p. 100). The services provided included housing, schools, recreational facilities, and infirmaries.

6.2 Land and its Use in Hāmākua

6.2.1 Geographic Extent of Hāmākua

The Hāmākua region can be defined in many ways: 1) the judicial district of Hāmākua; 2) the colloquial usage of the Hāmākua Coast; and 3) a region defined for the purpose of data analysis. This section will explain how Hāmākua is defined for the purposes of this report.

The judicial district of Hāmākua is located in the northeastern corner of Hawai‘i Island, between the districts of South Kohala and North Hilo (Map 1). This is the area described by county data for Hāmākua. Colloquially, Hāmākua refers to the portion of the island between Waipi‘o Valley and urban Hilo. This is a much larger area than the judicial district of Hāmākua, encompassing the judicial districts of Hāmākua, North Hilo, and a portion of South Hilo (Map 1).

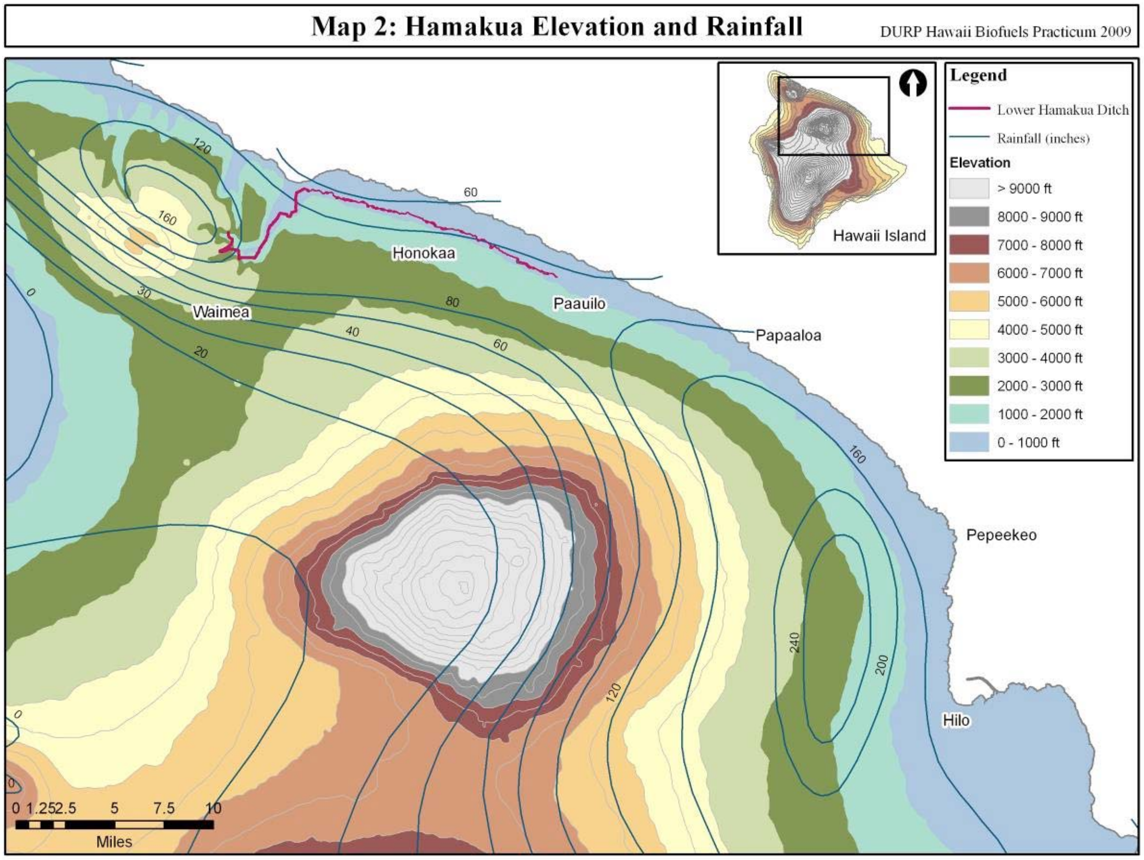


For data analysis, categorizing data specific to “Hāmākua” can be a challenge because the common definition of Hāmākua encompasses such a large area, including multiple judicial districts. Most data at the county level falls within judicial district boundaries. Including data for the district of South Hilo would skew data because South Hilo includes the city of Hilo – the island’s largest urban area, which is quite distinct from the rural region of Hāmākua. Most data analysis for the Hāmākua region avoids this potential source of error by excluding the district of South Hilo and defining Hāmākua as the area covered by the judicial districts of Hāmākua and North Hilo. For example, census tracts 219-221, describing Hāmākua, fall within these boundaries (Map 1) (Department of Health, 2008).

For the purpose of this report, “Hāmākua” refers to the whole region from the rim of Waipi‘o Valley to the banks of the Wailuku River, from sea level to the summit of Mauna Kea and over into the saddle region between Mauna Kea and Mauna Loa. To describe this region numerically, however, data will be aggregated from the judicial districts of Hāmākua and North Hilo, assuming those areas to be representative of the broader Hāmākua region.

6.2.2 Elevation, Slope, and Rainfall

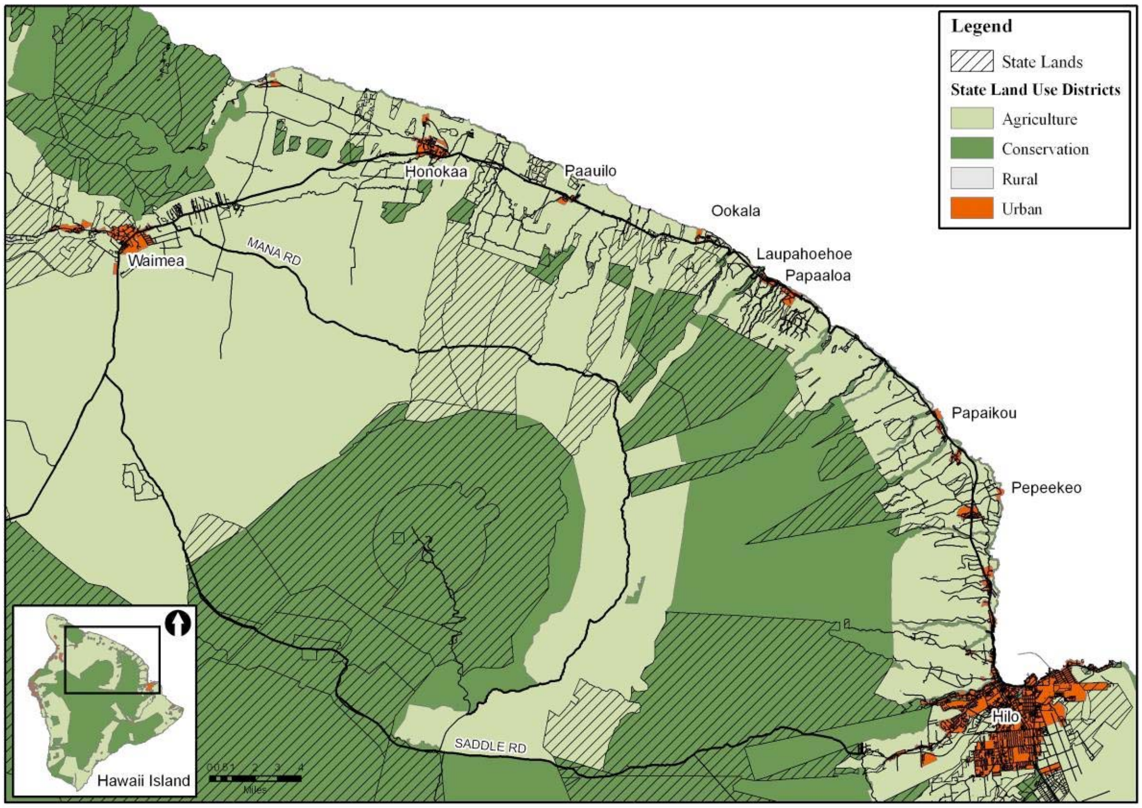
Hāmākua encompasses a large and topographically varied region with deep valleys, inland forests and an upland plateau, all with varying vegetation. Elevation ranges from sea level to 13,796 ft at the summit of Mauna Kea. Average annual rainfall varies from 20 inches to 240 inches (Map 2). Ground slope in much of Hāmākua averages 10 percent. Former sugarcane lands in Hāmākua (35,000 acres, distributed mostly along the coast in a 35 miles long by approximately 4 miles wide area) were considered steep enough to hinder large, mechanical plantation equipment (Kinoshita et al., 1999).



6.2.3 Zoning

State Land Use Districts. Zoning is an expression of the desired use of land. Like Hawai‘i Island, and the State of Hawai‘i in general, most of Hāmākua's lands are within the conservation and agricultural state land use districts (Map 3, Table 5). Statewide, 47 percent of all lands are in the agricultural district. Hawai‘i Island is very similar, with 47 percent of the island in the agricultural district as well, but this equal ratio represents 62.9 percent of all agricultural lands in the state. Hāmākua's 216,316 acres in the agricultural district represent 11.2 percent of all agricultural lands in the state.

Map 3: Hamakua State Land Use Districts DURP Hawaii Biofuels Practicum 2009



County Land Use Pattern Allocation Guide (LUPAG) and Zoning. The County of Hawai‘i expresses its vision for land use in the General Plan using a Land Use Pattern Allocation Guide (LUPAG) map (Map 4). The Zoning Code is the legal instrument that implements that vision (Map 5).

LUPAG. Most lands in Hāmākua are classified in the county's LUPAG designations of Conservation, Important Agricultural Land, and Extensive Agriculture. Important Agricultural Lands are those with the potential for sustained high agricultural yields because of soil, climate, topography, or other characteristics. The Extensive Agriculture designation includes "lands that are not capable of producing sustained, high agricultural yields without the intensive application of modern farming methods and technologies due to certain physical constraints such as soil composition, slope, machine tillability and climate" (County of Hawai‘i, 2005, p. 14-9). Other less intensive agricultural uses such as grazing are included in this category.

Table 5
State land use districts by state, county, and region

	STATEWIDE		HAWAI‘I ISLAND		
	acres	*% state*	*acres*	*% island*	*% state*
Conservation	1,973,631	48.0%	1,304,347	50.7%	66.1%
Agriculture	1,930,224	46.9%	1,214,040	47.2%	62.9%
Rural	10,370	0.3%	1,291	0.1%	12.4%
Urban	197,663	4.8%	53,722	2.1%	27.2%
Total	**4,112,388**	**-**	**2,573,400**	**-**	**62.6%**

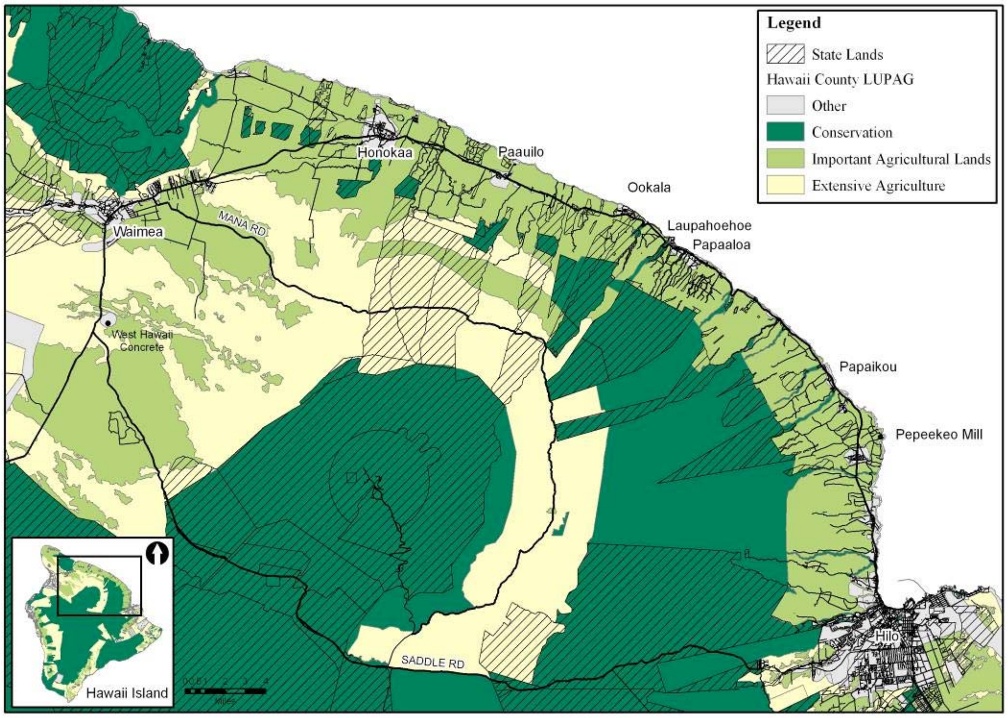
	HĀMĀKUA[1/]			
	acres	*% region*	*% island*	*% state*
Conservation	355,915	62.0%	27.3%	18.0%
Agriculture	216,316	37.7%	17.8%	11.2%
Rural	84	0.01%%	6.5%	0.8%
Urban	1,649	0.3%	3.1%	0.8%
Total	**573,964**	**-**	**22.3%**	**14.0%**

Note: Data from DBEDT State Data Book 2007 and the County of Hawai‘i Planning Department 2005.
[1/]Hāmākua is defined as the sum of judicial districts of Hāmākua and North Hilo.

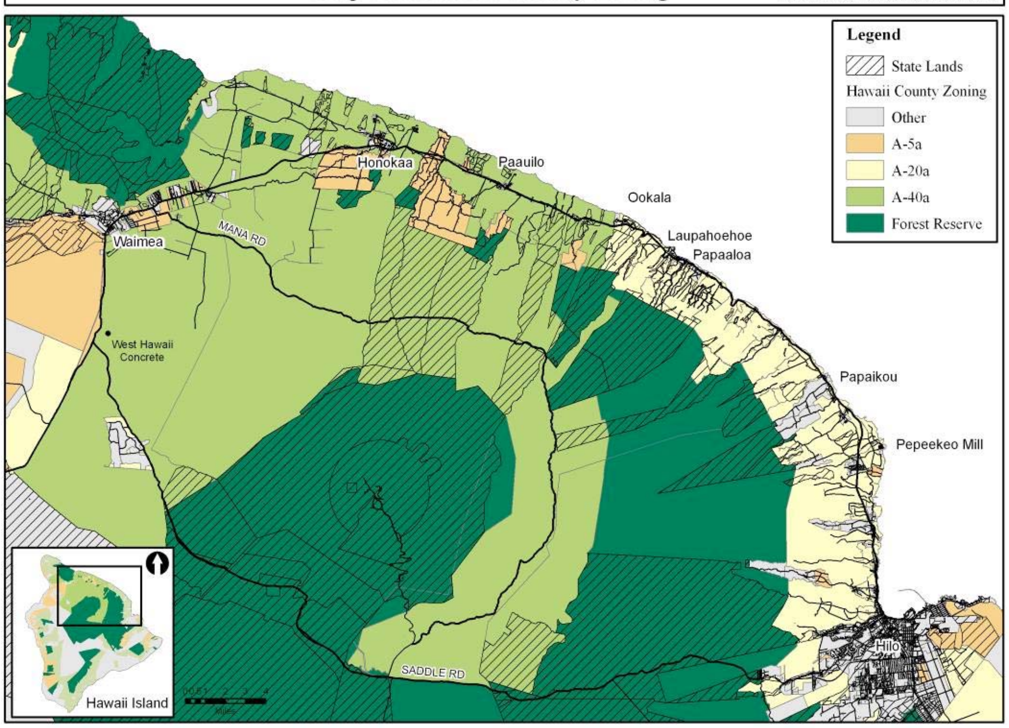
County Zoning. Most lands in Hāmākua fall in the county's Forest Reserve or agricultural zones. Lands in the agricultural zone are identified by the letter "A" followed by a number and a lower case "a" which indicate the minimum number of acres for each lot (County of Hawai‘i, 2009). Hāmākua's zones A-40a, A-20a, and A-5a then have minimum lot areas of 40, 20, and 5 acres, respectively. Permitted uses in these agricultural zones, besides crop production, include almost anything but urbanization, such as agricultural processing facilities, very low density residential, recreational facilities that are not completely enclosed, and even golf courses (by special use permit).

Agricultural Lands of Importance to the State of Hawai‘i (ALISH). The State and County have both expressed a desire to use much of the land in Hāmākua for agricultural purposes, but not all agricultural lands are created equal (see explanation in section 1.2.1). The Agricultural Lands of Importance to the State of Hawai‘i (ALISH) classification provides a more accurate depiction of the classified lands' potential for agricultural production. Land classified as ALISH is one criterion for being eligible to be declared IAL (HDOA, 2008).

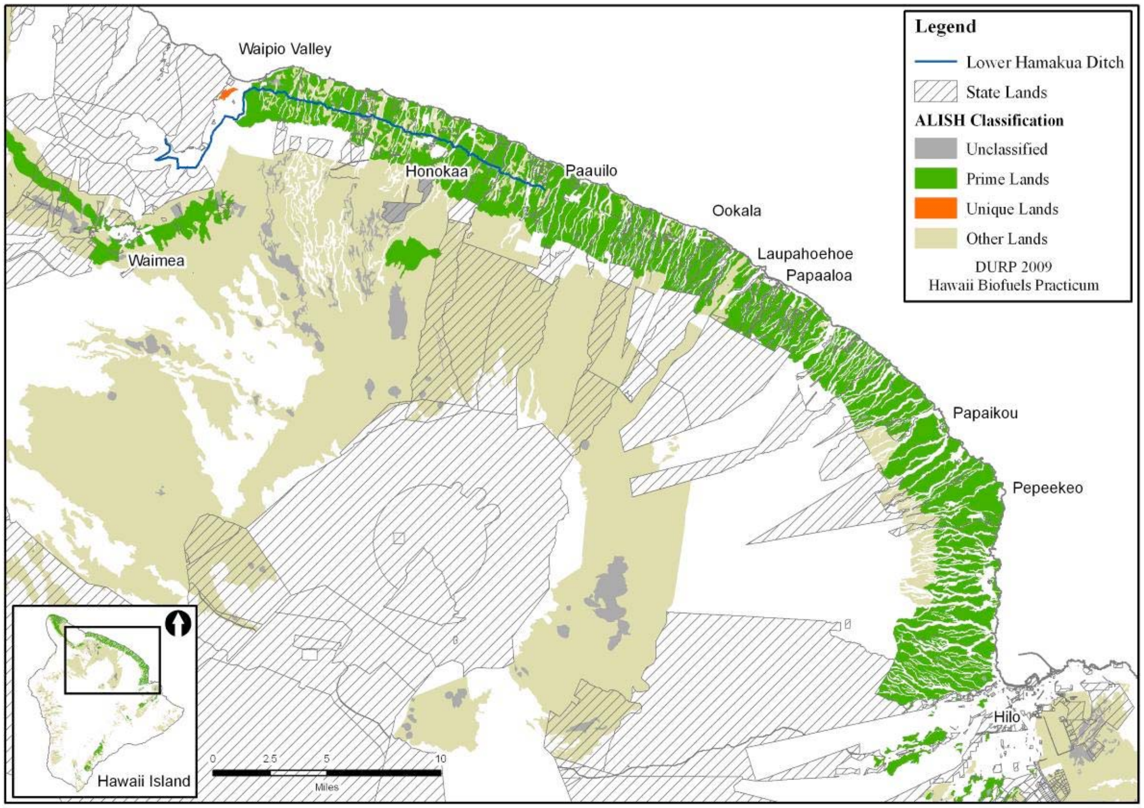
Map 4: Hamakua County LUPAG DURP Hawaii Biofuels Practicum 2009



Map 5: Hamakua County Zoning DURP Hawaii Biofuels Practicum 2009



Map 6: Hamakua Agricultural Lands of Importance to the State of Hawaii (ALISH)



ALISH classification considers a broad range of factors, including soil type, climate, moisture supply, and input use. ALISH "Prime Lands" have the soil quality, growing season, and moisture supply needed to produce sustained high yields of food, feed, forage, and fiber crops (HDOA, 1977). In Hāmākua, ALISH Prime Lands are located in a belt at the lowest elevations (Map 6). ALISH "Unique Lands" are those other than Prime for unique high-value crops such as coffee and taro (HDOA, 1977). In Hāmākua, ALISH Unique Lands are located in Waipi‘o Valley, where taro is cultivated. ALISH "Other Lands" are important to the State for production, but they are excluded from the Prime and Unique categories due to limiting properties such as susceptibility to erosion, limited rooting zone, slope, flooding, or drought (HDOA, 1977). Much of the higher elevations of Hāmākua fall in this category.

6.2.4 Agriculture in Hāmākua

Like the County of Hawai‘i, Hāmākua is agriculturally oriented. The county's three largest agricultural industries—flowers and nursery products, vegetables, and macadamia nuts—accounted for over 50 percent of the value of the county's agricultural products in 1997 (County of Hawai‘i, 2005). Besides these three, Hāmākua's agricultural products include eucalyptus trees, cattle, ginger, bananas, orchids, tropical fruits, cacao, papaya, watermelons, tomatoes, kava, coffee, taro, and other vegetables (County of Hawai‘i, 2005).

6.2.5 Water in Hāmākua

Groundwater sources are considered abundant in the Hāmākua region. Combined groundwater capacity from sources in Waimanu, Honokaa, and Pa‘auilo was, in the early 1990s, 201 million gallons per day (mgd), while consumption was 4.4 mgd (Kinoshita et al., 1999). Water was pumped by the Hawai‘i County Department of Water Supply, and by domestic, military, and commercial systems.

Agricultural land use in the driest part of Hāmākua is facilitated by the provision of water from the Lower Hāmākua Ditch (Map 2). The ditch was originally constructed about 100 years ago to divert stream water for the transportation of sugar cane stalks from the upland fields to the coastal processing mills. As the mechanization of sugar production advanced, the primary use of the water of the Lower Hāmākua Ditch became irrigation for the fields and wash water for the mills.

According to the Watershed Plan and Final Environmental Impact Statement, the initial capacity of the Lower Hāmākua Ditch was 40 mgd, and currently transports an average of 30 mgd from the head of Waipi‘o Valley to Pa‘auilo (Water Resource Associates, 2004). The closure of Hawaiian Sugar Company "idled about 21,400 acres of former sugar cane cropland in the Lower Hāmākua Ditch watershed area" (USDA, 1999, p. 9). The State's Agricultural Water Use and Development Plan studied the ditch in detail and recommended its maintenance to supply "new small-scale farming operations" (Water Resource Associates, 2004). The goal was to transform former plantation systems to diversified agriculture use as a means to achieve food self-sufficiency while supporting agriculture as one of the state's most important industries.

6.2.6 Urban District

Urban areas in Hāmākua are small and rare. Only 0.3 percent of the area is in the urban district, which is much lower than the averages for Hawai‘i Island and the State, at 2.1 and the 4.8 percent, respectively (Table 5). Hāmākua's urban areas are a product of the now defunct sugar industry, which created settlements in pockets along Highway 19 in Honokaa, Pa‘auilo, ‘O‘ōkala, Laupāhoehoe, Pāpa‘aloa, Pāpa‘ikou, and Pepe‘ekeo.

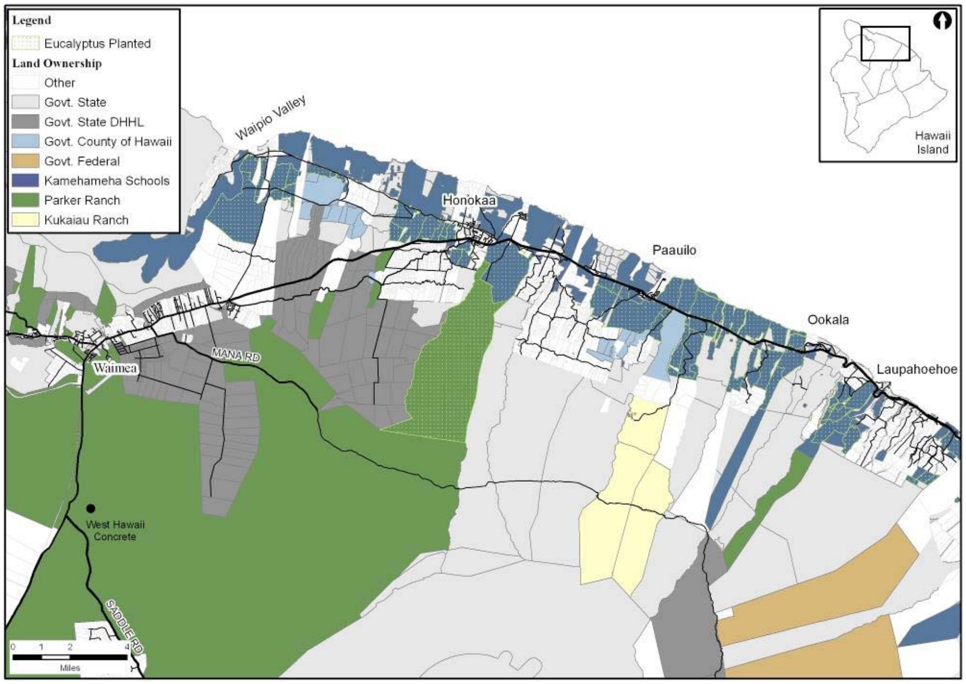
6.2.7 Land Ownership

Lands in Hāmākua are equally divided between government and private ownership (Maps 7 and 8). The State of Hawai‘i and Department of Hawaiian Home Lands (DHHL) own the government lands in Hāmākua. Private land owners with large holdings in the area include Kamehameha Schools (KS), Parker Ranch, and Kūka‘iau Ranch. Each landowner has specific interests and plans for their land, based on departmental missions and responsibilities, which are outlined below.

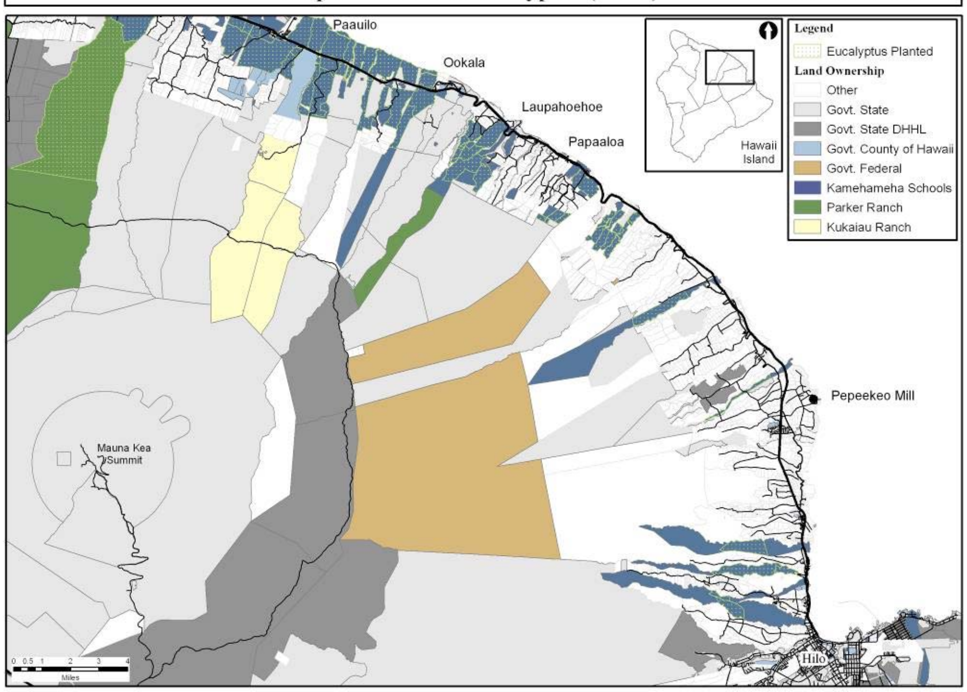
State. The State of Hawai‘i has an obligation to promote and maintain the use of agricultural lands for agricultural purposes. The State Constitution (Article XI, Section 3) requires the State to conserve and protect agricultural lands, promote diversified agriculture, increase agricultural self-sufficiency, and assure the availability of agriculturally suitable lands. Most state lands in

Hāmākua fall in the conservation district (Map 3). State lands in the agricultural district are

Map 7: Hamakua Eucalyptus (1 of 2) DURP Hawaii Biofuels Practicum 2009



Map 8: Hamakua Eucalyptus (2 of 2) DURP Hawaii Biofuels Practicum 2009



currently leased to cattle and other livestock operations.

Department of Hawaiian Home Lands (DHHL). The State Department of Hawaiian Home Lands (DHHL) has recently accelerated efforts to lease its lands to generate revenue for the provision of housing for Native Hawaiians (Pang, 2007; Quirk, 2007).

Nearly all DHHL lands in Hāmākua are within the state agricultural district. DHHL's Hāmākua lands are in two large blocks: Pu‘ukapu and Nienie near Waimea town and Humu‘ula on the eastern slopes of Mauna Kea. DHHL's Nienie lands are adjacent to Parker Ranch's eucalyptus plantation. Nienie was planted in eucalyptus in the 1930s and that timber can now be harvested (DHHL, 2002). Due to access limitations, DHHL plans to continue using this 612-acre parcel for agricultural uses rather than for residential development (DHHL, 2002). DHHL's Humu‘ula and Upper Pi‘ihonua parcels on the southeastern slopes of Mauna Kea cover an area of over 39,000 acres, at high elevations between 5,800 ft and 9,500 ft, and they are currently leased for cattle grazing (DHHL, 2002). It has been recommended that these lands be divided into 78 pastoral lots of 100 acres each (DHHL, 2002).

One project on the Humu‘ula lands on the slopes of Mauna Kea, involves 13,000 acres, which are infested with gorse. A community-initiated project, the Humu‘ula Renewable Energy Partnership Project, run by Duke Kapuniai is clearing that gorse and transforming it into biodiesel; it is estimated that 27 million gallons could be produced using on-site Flash Carbonization technology. The removal of the gorse, which could take decades, produces up to 26,000 gallons of biodiesel per acre (Gionson, 2009).

Kamehameha Schools. Kamehameha Schools is the largest private landowner in the state. Income generated from leasing its lands for residential, commercial, resort, and agricultural purposes, as well as investments, fund educational endeavors. As a trust, Kamehameha Schools has a duty to "balance educational and cultural values with economic returns" (Kamehameha Schools, 2000).

Following the close of Hāmākua Sugar Company in the 1990s, Kamehameha Schools purchased 29,500 acres of former Hāmākua Sugar Company land as an investment. They put around 50 percent of the land into a eucalyptus plantation, 25 percent in conservation, and 25 percent in agriculture use, primarily ranching (Imua TV, 2002).

Parker Ranch. With over 30,000 head of cattle on 130,000 acres of land, Parker Ranch is the largest ranch in Hawai‘i and one of the largest cattle ranches in the US. The ranch owns 105,000 acres, and the other 25,000 acres of the ranch's lands are leased from the state, DHHL, and Queen Emma, among others. Eucalyptus is planted in approximately 4,000 acres of the ranch's lands in Hāmākua. The rest is used primarily for grazing cattle.

In 1992, following the death of the ranch's last owner, Richard Smart, the ranch was left in a trust to support healthcare, education, and charitable giving through named beneficiaries in the Waimea community. The Parker Ranch Foundation Trust beneficiaries include Parker School Trust Corporation, Hawai‘i Preparatory Academy, Hawai‘i Community Foundation's Richard

Smart Fund, and North Hawai‘i Community Hospital.

Kūka‘iau Ranch. Kūka‘iau Ranch is located on the slopes of Mauna Kea between Pa‘auilo and ‘O‘ōkala. Approximately 650 of the ranch's 10,000 acres are leased from Kamehameha School and the State. The ranch's primary income generators are 1600-2000 head of cattle and timber salvage operations.

6.3 Population: Demographics and Employment

North Hilo and Hāmākua are Hawai‘i Island's two least populated judicial districts, a trend that is expected to continue in the future (County of Hawai‘i, 2005). Even combined, the population is still less than the next least populated district (Ka‘ū).

The current demographic makeup of the Hāmākua community is a direct reflection of the decades of immigration to the Hāmākua region to work on the sugar plantations. The area is now home to a diverse mix of Native Hawaiians, Filipino, Japanese, Portuguese, Hispanic and other ethnic groups. According to the 2000 Census, Asian/ Pacific Islanders make up 44.4 percent of the population, Caucasians 43.9 percent, Hispanics 9.8 percent and less than one percent of the populations are Native American or African American (Hāmākua Health Center, 2009). A comparison of the 1990 and 2000 Census shows an increase of 10 percent in the population of Hāmākua with a current total population of 7,828 (Hāmākua Health Center, 2009).

In the Hāmākua region, since the closing of the Hāmākua Sugar Company a decade ago, employment options have been limited. Hāmākua ranked in the bottom six districts for per capita income in the State at $13,487, compared to the State average of $21,888 (DOH, 2007). Yet, Hāmākua has relatively low unemployment compared to other districts. In 2007, Hāmākua's unemployment rate was 2.5 percent in comparison with Ka‘ū at 7 percent and Hawai‘i County in general at 3.3 percent. However, local unemployment has likely increased in the recent recession, where statewide unemployment has more than doubled in the last year (DLIR, 2009).

For Hawai‘i County, the State Data Book (DBEDT, 2000) categorizes most of the labor force as "Educational, Health and Social Services" and "Arts, Entertainment, Recreation, Accommodation and Food services." These sectors have grown significantly over the past 3 decades: "Educational, Health and Social Services" has increased from 4,790 workers in 1980 to, 12,287 in 2000; and "Arts, Entertainment, Recreation, Accommodation and Food services" from 4,154 workers in 1980 to 11,462 in 2000. "Agriculture, Forestry, Fishing and Hunting", and has increased only minimally from 4,272 workers in 1980 to 4,600 in 2000. The total labor force has grown from 38,150 workers in 1980 to 64,979 in 2000 (DBEDT, 1980, 1990, 2000).

6.4 Community Plans

The *Hāmākua Regional Plan: From Kaia‘akea to Waipi‘o* (HRP) was a joint effort involving the Hāmākua Coast and other Hawai‘i county communities, State government, and the private sector. In November 1990, the plan was endorsed to serve as a regulatory guide for the Hāmākua region. The plan's goal was to rescue Hāmākua Sugar Company from foreclosure over a $130 million debt by maximizing the value of surplus sugar lands, which comprised a substantial portion of the Hāmākua region. Selling the lands would have eliminated the company's debt, halting bank acquisition of the sugar company and its lands. However, in the end, Hāmākua Sugar Company did foreclose. Nevertheless, the process of changing land use designations from low-density agriculture to higher density mixed-use or residential development continued (HRP, 1990).

The HRP divided the Hāmākua region into three zones: Kaia‘akea to ‘O‘ōkala, ‘O‘ōkala to Kukuihaele, and Kukuihaele to Waipi‘o. The first zone, Kaia‘akea to ‘O‘ōkala, was zoned Ag-20a for sugar cane production. The plan recommended "land use densities be increased… to enhance value as well as increase marketing possibilities" (HRP, 1990, p. 29). While higher densities were recommended in this zone, none of the land was recommended for rezoning as residential or mixed use.

The second zone stretched from ‘O‘ōkala to Kukuihaele and included 517 acres of lands to be sold and rezoned. The Hawai‘i County General Plan slated Pa‘auilo and Honoka‘a, located in this zone, for urban expansion. The HRP recommendation was to increase density for all of the 517 acres up for sale but "retain the remaining productive lands in as contiguous a configuration as possible" (HRP, 1990, p. 30).

The third zone spanned from Kukuihaele to Waipi‘o and was identified as "the lands with the highest potential market value" (HRP, 1990, p. 32). The plan identified these approximately 3,200 acres for multiple use development. Possible uses included master planned agricultural/residential use, a retreat resort as defined by the County General Plan, or golf courses with related facilities.

A more recent planning document, *A Plan for the Hilo Hāmākua Coast* (HHC), developed in 2000, was a community based economic development plan. It was done in response to the plantation's demise and the region's subsequent struggles. The executive summary noted that many people who live in this rural region "commute long distances to work, while others have succumbed to unemployment and face dismal prospects for meaningful work" (HHC, 2002, p. 3). This plan included extensive community input and utilized tools such as visioning to clarify important concerns residents had for the Hāmākua Region.

The objectives from this plan included "supporting regional agriculture and expanding marketing approaches for independent farms, agricultural cooperatives and hardwood forestry niches" (HHC, 2002, p. 16). All objectives were based on making the Hāmākua Region more self-sufficient in both employment and production. Many of its goals focused on locally owned businesses and land. This is in contrast to the land use ordinances from the 1990 plan, which encouraged corporations to buy newly zoned land for the building of golf courses and resorts.

The most recent plan, *Hāmākua Agricultural Plan: Sustaining Rural Hāmākua through Agriculture* (HAP), was finalized in 2006. This plan was created with significant community participation, identifying a vision for the Hāmākua region to maintain "land use polices that…

protect, preserve and support the welfare and continuation of true agricultural uses" (Hāmākua Community Development Corporation, 2006, p. 3). It also envisioned Hāmākua as a place where "children and children's children can expect to live and work surrounded by healthy, responsible and diversified agriculture" (HCDC, 2006, p. 3). The Hāmākua Agriculture Plan was intended to protect the agricultural lands of Hāmākua until a Community Development Plan for Hāmākua was written, adopted and implemented.

6.5 Large Projects Since Sugar

Generally, large projects have been met with equally large opposition. In 1997, Japan's Oji Paper Co. pursued the development of a pulpwood plantation and manufacturing plant. They sought to lease substantial acreage of public lands. Initially, Mayor Yamashiro and Governor Cayetano, along with other state agencies, supported the plan. Hāmākua residents, however, were unsupportive of the project (Thomson, 1997). After months of activism, the State Board of Land and Natural Resources (BLNR) unanimously rejected the plan.

Another publicly opposed proposal, down the coast from Hāmākua, was the Aman project, a projected two golf course development in Kukuihaele. The plan incorporated a high-end resort, worker housing, and an upscale residential neighborhood. This proposition, like several before it, encountered grassroots activism staunchly opposed to the development of the quiet, country coastline. In the end, the project was unable to meet critical deadlines and stalled amidst community opposition.

7. Eucalyptus Plantations and Hāmākua

Currently, about 14,000 acres of eucalyptus trees are planted on former sugar lands in Hāmākua. Ownership of and plans for the trees have changed several times since the mid-1990s. The current managers plan to harvest these trees and allow the next rotation to re-grow via the coppice method. This section discusses applicable management practices for these trees, provides an overview of the history of the eucalyptus trees in Hāmākua, and describes possible uses for the mature trees. It will also explore the relationship between forestry and the cattle industry. This section draws on information obtained from both the broader literature on forestry in Hawai‘i and information obtained during interviews.

7.1 General Characteristics and Uses of Eucalyptus Plantations

Eucalyptus trees have been planted extensively in the state of Hawai‘i and on Hawai‘i Island for many purposes, including veneer, construction, and chipping for paper pulp or electricity generation (Little & Skolmen, 1989). Globally, plantations of fast-growing trees such as eucalyptus are commonly used for biomass production, native forest restoration on degraded sites, and value-added wood products. For example, most eucalyptus plantations outside of Australia are utilized for fuel, low-grade roundwood such as poles or posts, or wood pulp (Hills & Brown, 1984). Approximately 5 percent of Australian eucalyptus goes to higher quality veneer or sawn timber (Hills & Brown, 1984). In Australia, however, large, mature trees are used primarily for sawn products (Hills & Brown, 1984).

Management decisions for eucalyptus plantations in Hāmākua include rotation time and coppicing. Short rotation time for eucalyptus is between three and seven years (Sims & Venturi, 2004; Sims, Maiava & Bullock, 2001; Wei, 2003, p. 52). Fast-growing, short-rotation, coppicing hardwoods such as eucalyptus are often the preferred species for biomass production in warmer temperate and sub-tropical climates (Mead, 2001 cited in Mead, 2005), and large tracts of it have been planted in over 100 countries (Campinhos, 1999). However, detailed silvicultural guidelines for managing eucalyptus coppice plantations have not been developed (Sims et al., 2001). Year-round harvesting of short rotation coppice eucalyptus offers many opportunities, including: minimizing delivery costs to the power plant, allowing for variability in harvesting to meet variations in demand, and allowing for additional growth by leaving the trees standing as long as possible before harvesting (Sims & Venturi, 2004). Year-round harvesting could also have positive labor implications by spreading work opportunities over time (Sims & Venturi, 2004).

A coppice system is commonly used to manage short-rotation eucalyptus crops to be used for firewood, poles, and pulpwood because they show “remarkable coppicing power” (Evans, 1992; Hills & Brown, 1984). Under the coppice method, a forest crop is raised from shoots produced from the cut stump (called stools) of the previous crop, allowing natural regeneration from the stool rather than from seed. For large-size timber material, usually only one or two strong coppice shoots per stool are grown for the full rotation, eventually becoming almost indistinguishable from a planted tree (Evans, 1992). The growth of *E. grandis* stands by coppicing after clear-cutting is so reliable that usually no other method has to be considered over a number of rotations (Hills & Brown, 1984). Commonly, two to five crops are harvested before stools require replacement, because in each rotation a few stools die (Evans, 1992; Hills & Brown, 1984). *E. grandis* stool mortality ranges from 2-8 percent per rotation (Evans, 1992).

Benefits of coppicing include reduced costs and faster growth, among others. Coppicing keeps the stumps to hold down the soil, and it reduces costs by eliminating the cost of replanting (Hills & Brown, 1984; Mitchell, 1995). Initial growth of coppice is often rapid (Evans, 1992). Yield from the first coppice crop is normally higher than the seedling crop, but there is a decline in subsequent rotations, approaching that of the planted seedlings (Evans, 1992; Hills & Brown, 1984).

For biomass and bioenergy production, multi-stem coppiced stands often produce more biomass than planted stands (Harrington & Fownes, 1995; Sims et al., 2001), a trend that has been attributed to faster canopy development (Harrington & Fownes, 1995). All of these are related to the greater number of shoots per plant in a coppiced stand for biomass production, an attribute that would not be present in the single-stem coppiced stands on Kamehameha Schools land (Sims et al., 2001).

In addition to biomass production, eucalyptus plantations have elsewhere served as a catalyst for native forest regeneration. On degraded tropical landscapes, including agricultural lands and pastures long devoid of native forest cover, timber plantations of exotic species have been shown to serve as potential catalysts for native forest restoration (Parotta, Turnbull, & Jones, 1997; Proe, Griffiths, & Craig, 2002). The catalytic effect of plantations is due to changes in understory microclimatic conditions, increased complexity of vegetation structure, and development of litter and humus layers, all of which lead to improved light, temperature, and moisture conditions for native seedling growth (Parotta et al., 1997). Factors limiting native forest regeneration beneath timber plantations include competition with grasses (Guargarita, 1995; Parotta, 1995) and the presence of livestock, which has been shown to suppress understory growth, presumably through grazing and trampling (Haggar et al., 1997).

In existing *Eucalyptus saligna* plantations on degraded agricultural lands in Hāmākua, where native seeds are locally scarce, there is significant understory development. The understory is dominated by non-native plants, many of which are invasive species, such as *Psidium cattleianum* (strawberry guava) (Ostertag, Giardina, & Cordell, 2008). Even in close proximity to native seed sources, invasive pressures are strong (Harrington & Ewel, 1997). These results indicate that exotic tree plantations on Hāmākua's former agricultural lands are unlikely to facilitate native biodiversity without active restoration efforts such as direct planting of native seedlings (Ostertag et al., 2008).

7.2 Existing Eucalyptus in Hāmākua

In 1994, Kamehameha Schools purchased 29,500 acres of former Hāmākua Sugar Company land as an investment. They placed around 50 percent of the land into the tree farm, 25 percent in conservation, and 25 percent in agriculture use, primarily ranching (Imua TV, 2002).

For the tree farm, Kamehameha Schools leased the land to Prudential Financial, Inc., a global business with a very small portion in the timber industry that planned to grow eucalyptus with the goal of producing chips for the pulp and paper market. Prudential then sold the timber operations to Hancock Natural Resources Group. Forest Solutions International was the forest manager for both companies. In summer 2008, global investment management firm Grantham, Mayo, Van Otterloo & Co., LLC (GMO, LLC) secured the lease and timber and American Forest Management (AFM) became the forest manager.

Today on the ground in Hāmākua, there are nearly 14,000 acres of *Eucalyptus* trees, 9-12 years old, on Kamehameha Schools land (Maps 7 and 8). Kamehameha Schools owns the land on which the trees are planted. GMO LLC's lease with Kamehameha Schools runs through February 2020. AFM is planning for the harvest of the trees, at which point GMO LLC will sell the timber to a buyer of their own choice.

There are agreements currently with two local buyers. Approximately 25 trees per week are sold to Hāmākua Mushrooms for use as a growing media for their wood-decomposing mushrooms. GMO LLC has also recently entered into a Wood Supply Agreement with Tradewinds Forest Products to supply veneer logs. Other potential buyers of the forest products harvested include private companies interested in developing biomass-to-energy power plants and potential liquid biofuel production companies.

AFM is planning to clear-cut the first harvest, grow the second crop via the coppice method, and then harvest the second crop prior to the end of GMO LLC's lease. Following the first harvest, the stumps will be allowed to resprout. The resulting coppice shoots will be thinned to one per stump and allowed to grow until the next harvest.

Downsides to coppicing were identified during the interviews. First, the next harvest is presumed to be smaller—although there was considerable difference in the estimates of regeneration amongst survey participants. The most optimistic estimated a nearly 80 percent regeneration rate while the least was estimated at 20 percent. Normally, the yield from a first coppice harvest is actually expected to be larger than the yield from the original crop, even though a few stools will die (Sims et al., 2001; Evans, 1992). Factors that influence regeneration rates and biomass yields include harvesting practices, species, age of rootstock, population density, length of rotation, and time of harvest (Sims et al., 2001). Second, the next crop is less valuable, from a hardwood perspective, because the coppice first grows out to the side from the stump, leaving the lower (and most valuable) portion of the tree curved. Third, singling the coppice is expensive and labor intensive (Evans, 1992). Fourth, replanting offers an opportunity to improve the crop's genetic makeup by planting seedlings with more desirable traits, such as fast growth, straight trunks, or disease resistance (Hills & Brown, 1984). These genetic improvements can lead to great increases in production volume of up to 60 percent (Mead, 2005, pg 252). The practice of coppicing does not allow the opportunity to make these gains in volume.

Coppicing necessitates clear cutting, a practice with a negative connotation, which AFM seeks to alleviate with management efforts. Coppice does not grow well in the shade of thinned stands (Hills & Brown, 1984, p. 124; Proe et al., 2002), so the trees will need to be clear-cut to expose the coppice to plenty of sunlight to maximize the growth rate of the second crop. The trees will be clear-cut using heavy equipment, leaving bark and leaves on the ground to replenish the soil. AFM plans to mitigate the impacts of clear cutting by leaving strips of trees as buffers on the makai (ocean-side) portions of the harvest areas. They are also considering leaving the farthest makai blocks of trees to act as buffers for collecting runoff while harvesting.

The harvest will be done using heavy equipment operated by a potential maximum of 3-4 crews of 5-6 operators per crew. This results in, at most, twenty-four forestry jobs. Jobs are likely to be part-time. There will be more truck drivers than loggers. It seems likely, however, that salaries will be more similar to construction jobs than agricultural jobs because of the level of skill needed to run machinery.

While AFM is clear on the methodology they would like to use for the harvest, the fate of the eucalyptus trees is still undecided. GMO LLC is actively seeking a buyer for the rest of the timber.

7.3 Potential Tree Crop Users

Some potential users for the eucalyptus trees on Hawai‘i Island include Tradewinds Forest Products LLC, Hū Honua Bioenergy LLC, and SunFuels Hawai‘i LLC. However, the existing eucalyptus acreage likely will not be enough to satisfy the potential combined demand.

Tradewinds Forest Products in ‘O‘ōkala is a forest products manufacturing firm that plans to produce energy with the tree byproduct. Tradewinds is currently trying to obtain financing to construct a veneer mill. They plan to use large, straight trees with no knots to make veneer (which can be used for plywood or engineered wood products). Only about 55 percent of each tree goes into the veneer market product; the rest will be chipped and either sold or burned in a boiler to produce electricity. The ash that comes out of the boiler can be used as fertilizer to return nutrients to the harvested land. Tradewinds has a supply agreement with GMO LLC for eucalyptus trees from Hāmākua.

Hū Honua has purchased the Pepe‘ekeo electric power plant and plans to convert it to run on wood residue (Hū Honua, 2009). The company has a contract with HELCO to sell the generated electricity. Eucalyptus chips will likely be the feedstock for approximately the next nine years after which the company's plan is to switch feedstocks. A 13 MW plant may require approximately 8,000 acres of eucalyptus (Bollmeier, Loudat & Kasturi, 2003). Feedstock will be chipped and burned in a boiler to produce a potential 22 MW of electricity. The scale of this plant is intended to provide firm power to solve the problem of solar and wind power intermittency. Operations will create 25-30 direct jobs and 100 indirect jobs (Hū Honua, 2009). In the future, Hū Honua is planning to feed its plant 260,000 wet tons of feedstock, which can be provided by approximately 20,000 acres of leucaena. However, leucaena is currently only being grown in small trials on Hawai‘i Island. One potential benefit of leucaena as a feedstock is using the leaves for cattle feed.

SunFuels is a biofuel production firm seeking to both grow crops for biofuel production and construct a conversion facility on Hawai‘i Island. SunFuels' parent company, CHOREN Industries, is partners with Royal Dutch Shell, Volkswagen, and Daimler Automotive Group. SunFuels proposes to use Biomass to Liquid technology to convert wood chips into a synthetic diesel fuel for use in important vehicles such as fire engines, school buses, and construction equipment. Michael Saalfeld, the founder and owner of SunFuels, recently acquired a controlling interest in Forest Solutions International.

The SunFuels biomass-to-liquid facility requires feedstock on a large scale: 130,000 – 200,000 bone-dry metric tons (BDMT) per year. It can be supplied, as one option, from tree crops grown on 25,000 – 50,000 acres. This would require additional acreage beyond the existing eucalyptus stock. Analyses by Forest Solutions International have identified four species of eucalyptus trees as ideal feedstock: *Eucalyptus grandis x urophylla*, *Eucalyptus grandis*, *Eucalyptus smithii*, and *Eucalyptus globulus*.

Forest Solutions International has conducted extensive research in eucalyptus production on Kūka‘iau Ranch and Parker Ranch lands, focusing on areas below 4,000-foot elevation with 40 inches of rainfall annually.

New Forests, another forest management company, owns the Ka‘ū and Parker Ranch tree plantations, and manages these plantations on behalf of Cambium Global Timberland Ltd, through Forest Solutions International. Although Forest Solutions International is no longer managing the eucalyptus trees on Kamehameha Schools land in Hāmākua, they remain active in forestry in Hawaiʻi Island. Lands in Kaʻū are perceived as slightly less desirable than Hāmākua lands due to volcanic risks such as lava flows, vog, and sulfur dioxide emissions, all of which can be hazardous to vegetation.

Some business models intend to employ a secondary product by utilizing forestry harvest debris as a feedstock for biofuel production, as has been suggested by some studies (Kinoshita and Zhou, 1999). Using the log for primary purposes and the debris for other uses is what forestry texts refer to as "whole-tree utilization", where all parts of a tree are harvested and used (Evans, 1992). This practice overcomes the problem of debris disposal, but it brings other dangers of nutrient depletion from the soil. The negative effects of soil depletion outweigh the small gain in dry matter production (Evans, 1992). Silviculturally, the ideal treatment is for the debris to be broken up into small pieces and left scattered as mulch (Evans, 1992). AFM's plans to leave debris on the ground mirror this practice.

7.4 Potential Job Creation

From both public meetings and interviews, there are an estimated 55 to 79 new jobs created from putting 14,000 acres of tree crop into biofuel production. As stated in a public meeting, harvesting the trees will be highly mechanized and thus there will be 5 to 6 people per crew, with 3 to 4 crews. Because these jobs require skills in operating heavy machinery, it is likely that their pay will be more similar to that of construction workers than other forestry jobs in the State. For this reason, the estimated pay for these jobs is $68,600 annually. Hū Honua, a potential 22 MW bioenergy electricity producer, estimates it will employ 25 to 30 workers on Hawaiʻi Island (Hū Honua, 2009). There will also be 15 to 25 people employed to transport trees and other products. Table 6 displays estimates for direct employment of three main stages of biofuel production.

Table 6
Possible Bioenergy Employment from the use of existing trees (14,000 acres)[1/]

Stage	Function	Number	Average Salary (Statewide)[3/]
Forestry	Mechanized harvesting	15 - 24	$68,600 [3a/]
Conversion	Power Plant employees[2/]	25 - 30	$41,500 [3b/]
Distribution	Trucking	15 - 25	$46,500 [3c/]
	Road maintenance	Unknown	
TOTAL POSITIONS		***55 -79***	

[1/]Includes data for forest management (including harvesting), conversion to electricity, and known support activities. Estimates were obtained from interviews, companies' websites, and companies' presentations at the January 13, 2009 Bioenergy meeting in Honokaʻa.
[2/]Indirect conversion jobs, estimated by the conversion company to be around 100, were not included because of a lack of detail of their exact nature.
[3/]From the 2005 State Input-Output Table (DBEDT, 2008)
[3a/]Forestry mechanized harvesting is average wage in construction

[3b/]Conversion salary comes from average manufacturing salary (excluding petroleum manufacturing)
[3c/]Trucking salary comes from average trucking salary

This estimate does not include jobs potentially created from Tradewinds Forest Products, as there will likely be the need for more acres of trees planted in order to support the operations of both Tradewinds and Hū Honua. For example, using general estimates from Bollmeier et al. and Sims et al., more than 14,000 acres would be needed to produce 24MW of electricity.

The issue of agricultural job creation is complex and merits further analysis. While job creation is most often thought of as a positive outcome of a project, unmet labor demand can also be a reason that projects fail. Information gathered in interviews, as well as data on agricultural laborers within the State, suggests that it has typically been difficult to assemble a sizeable agricultural workforce since the demise of the plantation systems. Although there are relatively few jobs provided on a per acre basis from tree crop biofuel production, the jobs provided are relatively high-skilled.

7.5 Impacts to Cattle Industries

With food crop production occurring primarily in Hāmākua's lower elevations, and biofuel companies stating they will not compete with food production for the use of those lands, the remaining land use in competition with biofuel tree crops is cattle production.

The Hawai‘i cattle industry has been in a slow decline since the 1970s, with reductions in both head of cattle and acres of grazing lands (Moniz, 2007). The most important aspect of beef production in the state is competition from the continental US, where economies of scale lower costs. In the 1990s, most local finishing, slaughter, and processing operations were discontinued because they could no longer compete with cheaper beef that was fed, processed, and vacuum packed on the mainland (Moniz, 2007).

Most large ranches in Hawai‘i are now "cow-calf" operations. This means that they maintain herds solely to produce calves, which are then shipped to the mainland for further growing and finishing. Recently, demand for grass-finished beef has increased, which has increased the viability of finishing cows within Hawai‘i. Local ranches are all looking to increase their production of grass-finished beef, which means the industry can both start and finish production on-island.

To preserve the ranching industry, which has been a driving force on Hawai‘i Island for over 160 years, the Hawai‘i Cattlemen's Council (HCC) has identified a number of ways to promote the industry's well being. One of the most important policies is "no net loss" of grazing capacity, particularly on State land. The specification of "State land" here is important because many ranches already depend on leased State land to maintain their current grazing capacity. Transfer of these leases from current ranching lessees to biofuel production firms could be devastating to the ranches losing land, and HCC can be expected to lobby heavily in favor of cattle interests as they have in the past.

However, it may be possible to develop co-production of biofuel tree crops on grazing land.

This may provide an opportunity to increase grazing capacity. For example, if areas that currently are not being grazed are slated for production of tree crops, and the understory is suitable for grazing, that would be a net increase in grazing capacity, which HCC might support. Because of logistical concerns, however, AFM is not currently intending to allow for grazing under the eucalyptus trees it manages.

Forest Solutions International is working on possible silvopastoral trials on Parker Ranch lands. Silvopastoral trials are relatively long-term endeavors that involve evaluating various types of trees, their spacing and corresponding fodder production, and grazing opportunities.

Local ranches are no strangers to alternative energy. Kahuā Ranch in Kohala pioneered wind energy production on grazing lands in the 1970's and 80's. It currently produces its own power using both wind turbines and solar panels. Ponoholo Ranch in Kohala uses solar panels to power their electric fences. And Parker Ranch, a major landowner on the island and in Hāmākua, uses solar power for pumping its water. It may be possible that biofuels be considered by ranchers as an opportunity from the energy point of view as long as growing them entails no loss of grazing capacity or other production disruptions.

While struggling to compete with low-priced beef from the mainland, local ranches are seeking to diversify their incomes by generating multiple streams of revenue from a single piece of land. Both Parker Ranch and Kahuā Ranch engage in agricultural tourism activities like horseback and ATV riding on grazing land. Both ranches also rent their facilities and space for film production and events such as meetings and weddings. Kahuā Ranch has also dabbled in diversified agriculture and communications infrastructure. Kahuā has grown niche products such as tomatoes in their greenhouse, and has experimented in growing pumpkins on a small scale, but both have been discontinued due to poor returns. It has also taken advantage of another income source available to ranches—the provision of land for communications infrastructure, such as transmission, relay, and radar towers. These towers can all be located on a single hilltop, generating income from a small area of land, with few demands on the ranch. Ranches are diversifying their sources of income, but they are doing so in ways that really complement cattle production. Tree crop production for biofuels is seen as potentially reducing cattle production because the trees shade out grass, which is necessary for cattle production.

8. Stakeholder and Expert Interviews: Key Themes

To better understand the technical, environmental, social, and policy issues surrounding biofuels, particularly in the Hāmākua region, this study interviewed 54 people organized into the following categories: 1) experts in energy, forestry, agriculture, and environmental management; 2) business leaders in forestry and energy; 3) business leaders in diversified agriculture, cattle ranching, and dairy farming; and 4) public officials and public employees in the areas of energy, water, and community planning.

Survey questions ranged from issues of species selection and best management practices to community sentiment and sense of urgency toward the use of biofuels. Interviews took place on O'ahu and Hawai'i Island between March and April 2009. For more details on the survey instrument and results, see Appendices II and III, respectively.

Several key themes surfaced in the interviews in relation to role of biofuels in Hawaiʻi's overall energy policy, the role of government in biofuel production, the overlap of food and energy agriculture in the Hāmākua region, and views on job creation and other community interests.

8.1 Overarching Themes

Biofuels are Potentially a Part of Hawaiʻi's Energy Solution

The majority of all respondents were open to the idea of biofuels being part of Hawaiʻi's energy solution, especially for the next 20 to 30 years. Some believed biofuels should be used for transportation while others favor electricity as an end-use, or both. Those who favored transportation as an end-use noted that biofuels can help address the current need for liquid fuels. They also cited that a large percentage of Hawaiʻi's energy consumption is attributed to transportation needs and the lack of other alternative fuel options in the transportation sector. Those who favored electricity generation as an end use cited the ease of integrating it into existing HECO and HELCO infrastructure. Those who believed both electricity and transportation were possible mentioned the extensive available land for potential crop production and the possibility of byproduct or complimentary usage. No one, however, viewed biofuels as a "silver bullet." One government respondent noted that there are "many pieces to this energy puzzle." Interviewees emphasized that other renewable energy options, such as solar, wind, hydrogen, hydroelectric, and geothermal, should be pursued as well.

Many of the respondents believed that the use of geothermal energy must be increased, especially since geothermal energy is abundant on Hawaiʻi Island. One government respondent suggested that "the incorporation of an expanded geothermal grid could stabilize current costs associated with other energy intensive processes. It is not tied into the vacillation of petroleum [prices] since it does not require pipes, fertilizers or nutrients." However, Native Hawaiian cultural and spiritual concerns have in the past deterred geothermal expansion.

Respondents felt that if biofuel production were to be deemed successful, it would not only need to be viable as a business, but also help improve the community economically and socially. According to the responses, the success of biofuel production and use could be measured against the degree to which such production and use perform the following actions: systematically reduce dependence on fossil fuels; help Hawaiʻi reach some level of energy self-sufficiency as a state; have lower environmental impacts and energy intensity of production than current sources; allow funds currently used for energy importation to be reinvested into local communities and businesses; and lower the cost of energy inputs.

Feedstock or Conversion Mechanism: The Starting Point for Biofuel Production is Uncertain

Despite openness to biofuels, respondents agreed that more information is needed before determining the economic, environmental, and social viability of biofuel production. Cited areas of uncertainty include yield information, because feedstock plant performance is unknown for Hawai‘i, and feedstock plant requirements, because the agricultural production of non-food plants is relatively new. Additionally, many of the conversion mechanisms other than direct combustion are also experimental and thus efficiency is not always known. One government respondent stated that in Hawai‘i specifically, there are no dedicated conversion plants, thus there is no reason for farmers to grow biofuel crops. But because we have no biofuel crops that require conversion, we have no reason to build a conversion plant. Due to these uncertainties, many respondents were hesitant to support biofuel production in Hāmākua.

The effects of biofuels on markets are also unknown, as all end-use products are not fully developed. One issue raised might be the difficulty of producing biofuels on a scale large enough to be profitable, particularly if it is only being marketed within the State. Additionally, there is no processing facility or supporting infrastructure for biofuel crops and there are no crops to justify building a facility. Again, since so much is uncertain or unknown in regard to biofuel production, many respondents thought that "jumping into biofuels would be premature." The industry is perceived as being new enough that there are limited examples to research and take as guidelines.

Government's Role in Biofuel Production is Complex

Some respondents believed that the government's role should be to represent community interests, investigate the environmental impacts of proposed projects, determine the various effects the project would have on the community, and monitor businesses to ensure they comply with regulations and minimize adverse impacts to the community. Others believed that government resources could be used to create policies for industry innovation, including providing educational resources for producers who wish to enter the market.

Some bioenergy companies believed that government should also provide tax credits and subsidies to help grow the industry. For example, one respondent said "companies will need to put in lots of money and take risk, but there needs to be a safety net for them." However, most outside of business were hesitant to support government subsidies that would mask the operating costs or "pick winners." One scholar noted "if [businesses] are not economically viable, they should not be propped up by government support." Most respondents seemed to agree that government funding should be used for research and development of biofuel technology, and government can function as a facilitating agent in the renewable energy process.

Some respondents appeared to disagree on whether the current policies and procedures—such as permitting and opportunities for community input—are helpful and necessary for due diligence and vetting of an incoming industry or are merely creating hurdles that impede industry development. There seems to be a difference between perceptions about policy content and its implementation.

8.2 Land Use Themes

Context Matters: What about the Existing Trees?

Independent of the desirability of biofuels in Hāmākua, eucalyptus trees already occupy 14,000 acres of Kamehameha Schools land. Many respondents acknowledge that something needs to be done with the trees; some trees have been there for over a decade. The sugar boom and bust has made the community cautious about large projects. One government respondent noted that "when sugar went down, there was an emergency situation; Hāmākua got railroaded into the eucalyptus. Some people are still upset at how they were 'rushed into it.'" Consequently, "This adds to our hesitancy to jump into something quick." On the other hand, some respondents indicated the eucalyptus plantations were quickly planted to provide environmental benefits, such as control of erosion. This was particularly pressing given the depleted state of former sugar cane lands.

Combined with this concern over process, disagreement about the best use of the planted land, the highest value of the trees, and the environmental impacts of the trees has generated controversy in the community. Compounding the situation, misinformation about the science and tree species has further confused people about the desirability of potential long-term projects that would involve replanting or coppicing (see Section 7).

Some respondents saw the recent bioenergy proposals as "one of the best ideas that have emerged in recent years," while others were more in favor of traditional hardwood industries. Several survey participants were open to complementary uses of the eucalyptus and some were already doing it. One bioenergy company stated, "A tree is like a cow. When you have a cow you are looking at 90 percent hamburger and 10 percent steak. A tree is the same way, 90 percent hamburger/chips and 10 percent veneer/steak … Of all the trees standing 5-10 percent is veneer quality at the stage and age they are now." For example, Tradewinds, one of the companies with very specific plans for the trees, would manufacture veneer that can be use for producing pre-engineered wood structural members (beams, posts), and then generate electricity out of the waste, while the sawdust could be used by mushroom producers.

For Better or Worse, Everyone Remembers Sugar

Many survey participants, including agricultural producers, energy businesses and government personnel, recognized the impression plantations have left on the region and the ways it influences group consciousness and decisions.

The sugar industry was the primary employer in Hāmākua for more than a century. Many respondents, including agricultural and energy producers, described the range of jobs from low-wage through highly skilled positions, with need for labor in the fields planting, harvesting, and trucking to work in the factories including machine operators, engineers, maintenance, and administration. Many respondents perceived a community-wide familiarity to the camaraderie and nature of the work. One respondent recognized the fortune of learning on the job, advancing within the company, and establishing long-term relationships – opportunities a young person may not have been afforded elsewhere in other industries. When sugar plantations closed, the effects extended beyond the loss of employment – a significant psychological effect on the area appears to continue to this day. Consequently, some respondents were concerned about the viability of biofuel operations in the area: the sugar plantation left, what could happen if biofuels leave?

The community continues to benefit from the infrastructure sugar companies developed for the production and transportation of the agricultural product. Development, construction and maintenance of roads and irrigation were a necessity for the trade and they are still a benefit for the island. It is now widely recognized that sugar cane planting and harvesting techniques led to environmental degradation, particularly in the use of pesticides, degradation, and erosion of soils. One respondent indicated that sugar caused six to ten feet of erosion in Hāmākua. Several respondents, from government employees to agricultural producers, noted that many of the practices in the plantation days would never be considered acceptable today. It is thus imperative that companies approach agricultural projects with increased environmental sensitivity.

While there is concern that large-scale plantation farming can drain soil of nutrients, making it unsuitable for diversified farming in the future, some scholars and agricultural producers nonetheless suggested that former plantation agricultural production land is best suited to go back into large-scale production. This is mainly because of the perception that economies of scale are needed for an economically viable biofuel production and because those lands have an inherently lower value from a conservation viewpoint. That is, biofuel production, whether as trees or other plants, should be plantation scale farming. This would mean potential biofuel producers should be aware of the risks of monocropping and prevent or mitigate its negative environmental impacts such as those related to fertilizers and erosion. Potential negative impacts from the equity point of view were not mentioned, although some respondents would like to see biofuel production based on cooperative farming systems.

Concerns about biofuel production revealed additional worries about increased traffic and noise and air pollution. In several interviews, respondents shared anecdotes about unsafe road conditions during sugar plantation days, mainly due to the volume of large trucks going through narrow secondary roads. Within community meetings, there has been substantial uneasiness regarding the size and number of trucks that would be traveling through Hāmākua as a result of biofuel production.

Agriculture is the Preferred Use for Fallow Land

Most agricultural respondents recognized that profitability is the key to keeping their operations alive. When participants (scholars, agricultural producers, bioenergy companies, and government respondents) were asked about the best use for fallow agricultural land in the Hāmākua region, responses revealed a wide range of opinions and suggestions. Not surprisingly, respondents typically recognized that their own activity was the most suitable for the land. However, most agreed that the best use depends on the needs of Hawai‘i and the Hāmākua community; economic and social feasibility; and what can be grown in the area. The main suggestions given for the best use of fallow land in Hāmākua were:

a) Agriculture–diversified or ranching
b) Forestry or silvopasture
c) Conservation or fallow
d) Limited development

a) *Agriculture–Diversified or Ranching*. Many respondents who preferred using the land for agriculture favored food production—produce, cattle, or other protein—over biofuels. All agricultural producers, along with several respondents from each of the other categories, favored most agricultural lands staying in food production, since Hāmākua has well-drained soils and high rainfall. Responses, though, differed on the type of agriculture that should be sustained. Some respondents wanted more diversified agriculture while others wanted to see cattle ranching, specifically grass-fed cattle, expand. Still others desired higher quality value-added products, such as aquaculture and niche export crops. Those in support of food production were not necessarily opposed to biofuel production.

b) *Forestry or Silvopasture*. Some respondents favored using fallow land for forestry and the production of value-added wood products and possibly bioenergy crops. Some agricultural producers suggested that forestland should be producing value-added wood products from *koa* or other hardwoods. These species tend to be slower growing but with higher-value. Those who favored the production of bioenergy crops tended to feel that faster-growing lower-value trees, such as eucalyptus, should be used. There is evidence, however, that hardwood trees such as koa do not grow at the same elevation as eucalyptus and, as such, there may not actually be a tradeoff between these types of forestry. Some respondents indicated that silvopasture–the merging of pasture and forestry–could be an option for fallow lands in Hāmākua. Cattle could graze in forestland and be redirected from sections in harvest. In this type of production the same portion of land could produce both trees, for biofuel or value-added wood products, and cattle, for food. Support for silvopasture and other forms of co-production with biofuel and food crops spanned across all categories of respondents. Several ranchers appeared to support co-production, as long as there is deep community involvement and a net preservation of grazing capacity.

c) *Land—Conservation or Fallow*. Some respondents, mainly scholars, were in favor of maintaining some of the fallow land in Hāmākua as conservation. Land that maintains a high level of bio-diversity and indigenous tree species are best suited for maintaining and restoring species' habitat. Lands best cited for conservation are contiguous and without potentially destructive animals, such as wild boars. Lands that have already lost biodiversity, such as those with eucalyptus farms and cattle pastures, are not well suited for conservation because of the challenges in bringing back the land to its original state. Several community members felt that the land should remain fallow. By having the land remain as fallow, vistas would be preserved and potential nuisances, such as pollution and noise, would be limited.

d) *Limited Development*. Some agricultural business respondents favored some development on agricultural lands. However, development would only be appropriate in specially designated areas after considerable review.

Housing. Respondents indicated that lands best suited for housing are adjacent to already built up areas and have pre-existing access to the required infrastructure, such as sewage, school, and roads. Smart growth principles were suggested to focus development and end the spread of sprawling “gentleman estates” that are currently consuming agricultural land. Also identified was the need for more affordable housing.

Research and training. Some interviewees felt small portions of agriculturally zoned land could be turned into mixed-use for agricultural research and training. One example was an agricultural destination center that would include a state-of-the-art demonstration working farm, agricultural and cultural learning center, farmers market, roadside concession stand, and retail nursery. Housing would be made available on the site so farmers could live on the land they farmed. Such a destination would serve local farmers, consumers, students, and visitors. One scholar mentioned a certificate and degree program at the community college level in agriculture production and business.

Community facilities. Another suggested possible use of the agricultural land was for the development of high demand community facilities. One suggestion that cropped up often was a processing and packaging plant for small agricultural producers to package and process local produce. Another proposal was an agricultural business center that would foster careers in agriculture, forest and wildlife management, business, science, and environmental studies.

Food Production Should be Maintained

Interview responses indicate two categories of food production in Hāmākua–ranching and diversified agriculture. Though census data indicates that a large majority of agricultural land on Hawai‘i Island is in production, mostly in range or pasture, respondents indicated that the community would welcome more food production. Ever-increasing land prices are a limiting factor for potential users. At the same time, many agricultural producers interviewed said that their children are not interested in taking over the family farm. This trend is reflected in the rising average age of principal operators, jumping from 55 years in 1997 to 58.6 years in 2007 (DBEDT, 2007; NASS, 2007).

Although the majority of respondents from all categories indicated diversified agriculture and ranching as the best uses of fallow lands in Hāmākua, the articulation of the possibilities for a growing local market differed. Responses in favor of increasing diversified agriculture often centered on niche crops. Several respondents stated that focusing sales solely on Hawai‘i Island was limiting and easily saturated. Thus, it is necessary to reach larger markets, such as Oahu. For example, even relatively successful producers of tomatoes and salad greens are marketing their produce as specialty products–local fruits and vegetables have difficulty competing with their imported counterparts. Despite this challenge, there is still community desire for more food production. However, there seems to be a current vacuum of concrete initiatives. While there may be a tradeoff between “food versus fuel,” the larger barrier seems to be the lack of a healthy agricultural industry. This stems from a number of pressures on land use other than agriculture.

Many of the ranches interviewed indicated interest or progress in expanding grass-fed cattle or milk production for the local market. While ranching is sometimes perceived as a lifestyle choice, respondents indicated that declining profitability is the main force behind business decisions of existing ranches. Several ranches and agricultural producers were open to the idea of co-production with biofuel tree crops as long as tree plantations do not reduce the productivity of food production.

8.3 Community Themes

Process Matters

A recurring theme in the interviews is the need for community participation in planning processes. Many respondents recognized community participation as instrumental and thus supported better community engagement, greater transparency, inviting all parties “to the table,” and having everyone play by the same rules.

Some government respondents perceived O‘ahu-based decision-making as detrimental to Hawai‘i Island’s community input process and participation. For example, in November 2008 when the BLNR met on O‘ahu with biofuel companies to discuss leasing state lands for feedstock production, the current lessees on those lands were not aware that “their” land was being discussed. The community was outraged when they realized that the fate of land use in the region was being determined with neither their knowledge nor consent. Holding the meeting on O‘ahu, creating at the very least geographic exclusion, was added insult. Respondents made it clear that the Hāmākua community needs to be involved in public dialogue before future changes are made. This dialogue needs to occur in Hāmākua, where residents, who are affected by these decisions, can be physically present.

Local government officials have taken the initiative in setting up public meetings where the industries are brought to the community to answer questions, but they thought it should be the industry making that contact on their own to introduce what they are planning and to build relationships with the community. When the community is not given clear, useful information from the start, a lack of understanding and a sense of distrust are created. Additionally, even though some potential biofuel producers have since hosted informational meetings for the community, as an attempt to make the process more transparent, many of those interviewed felt the meetings were, in general, too “fluffy” and did not answer many of their questions regarding community and environmental impacts.

Several respondents credit the Community Development Plan (CDP) process as an ideal venue to establish a new relationship, based on collaboration and transparency, between government and community. Historically, many problems have resulted from industries beginning operations without community participation or consent. The typical community recourse was to seek media attention, but respondents believed the community should meet face to face with businesses before reading about projects in the newspaper.

Everyone Wants to See Energy Costs Brought Down

Most respondents, from several sectors of the community, clearly stated that they would like to see a decrease in energy costs for consumers of locally-produced biofuels. A few respondents acknowledged there are green consumers who are willing to pay a premium for locally-produced biofuels but this may be a limited market. Agricultural producers were especially looking to cut costs; many were already using renewable energy technologies such as solar, hydropower, and wind on their operations. Some were amenable to biofuel co-production. Most stated they would consider using biofuel in farm equipment or generators if it were cost-competitive with conventional gasoline and diesel or were distributed closer to their operations.

Everyone Wants to Keep Hāmākua's Rural Characteristics–With Diverging Definitions of "Rural"

There are two foremost viewpoints on biofuel production as a case for rural economic development. One view supported biofuel projects based on the prospect of job creation. The second prioritized Hāmākua's landscape as a pastoral residential community. This does not mean all Hāmākua residents hold one of these two views. For example, some individuals were in favor of biofuels because they saw biofuels as a progressive energy solution, while others were against biofuels due to corporate distrust or scientific uncertainty. Others were unsure or indifferent for various reasons. The existence of these two viewpoints may be related to the changes provoked by the closing of the sugar company, including a massive loss of jobs and changes in land use.

Respondents recognize that many Hāmākua residents perceive biofuel development as an opportunity to seize stable, long-term, highly-skilled jobs in Hāmākua as opposed to long commutes for resort work on the Kohala coast. While some respondents were wary of big agriculture companies, they believed Hawai‘i benefited from sugar plantations through employment opportunities, housing, medical care, infrastructure, and by helping finance the provision of government services such as higher education. Respondents in the energy field suggested that forestry and biofuel production could create higher paying jobs with transferable skill sets. In fact, some agricultural and energy producers stated that current methods for harvesting and processing are closely related to construction jobs so that the proposed biofuels industry could be seen as a stepping stone to higher paying construction jobs. For example, approximately 16 to 24 mechanized harvesting jobs would be created if Tradewinds could begin operations.

Alternatively, before the last sugar mill closed, a community plan was drafted in an attempt to draw interest towards the real estate value of Hāmākua. Thousands of acres were rezoned for higher density and large lots were subdivided. Now, almost twenty years later, many of the people who were drawn to the Hāmākua region at that time are reluctant to see the lands go back into production. One concern is that properties might lose value. Also, some respondents displayed a strong protective sentiment towards their neighborhood, resisting environmentally disruptive changes. It appears that some residents chose to live in Hāmākua because of its quiet, rural landscape. Now, as invested residents, they might feel that industry is not an appropriate use of land, especially near residential areas.

This is not to say that those who hold these different opinions never agree. There appears to be a shared sentiment for more diversified agriculture and the potential for environmental degradation caused by biofuel projects is considered unacceptable. Both views espoused a desire to maintain the rural context of Hāmākua and agreed that they do not want it to be disrupted by large resorts or high-density subdivisions. Also, these two views, and the proportion of people leaning towards either opinion, might shift as projects gain more clarity, are better defined, and become vetted proposals.

8.4 Sense of Urgency in Incorporating Biofuels as an Energy Source Mix

Survey participants were asked to rate their level of urgency regarding biofuels as a primary energy source (Appendix 2). Of the more than 50 people interviewed, 43 provided responses to the following question: "On a scale of 1-10, 10 being the highest, how would you rate your sense of urgency in using bioenergy to address Hawaiʻi's current energy situation?"

Of the 43 respondents, 11 people (26 percent) felt that the urgency was a 10. About 86 percent, 37 interviewees, felt the urgency level was a 5 or higher; those who did not rank their urgency at least a 5 often ranked it a zero or "below." One respondent in this category thought that energy reliance was not an urgent problem compared to other societal ills and thus found the question to be irrelevant. This polarization was found throughout the interviews among participants from all sectors. Respondents either found Hawaiʻi's energy situation to be a pressing matter that needs to be addressed or they were not concerned with the situation and found other issues to be significantly more important.

The most common response from participants was 7. Nearly half of the respondents stated that research is critical to further develop alternative forms of energy and most felt that biofuels should be included in the energy mix. Respondents with low levels of urgency suggested that biofuels should not be the focus as much as other forms of renewable energy. Many of those who felt that bioenergy was urgent felt it is part of a renewable energy future, particularly because of its ability to convert into a liquid fuel.

Many respondents sensed that Hawaiʻi needs to lessen its dependence on fossil fuels—citing oil price fluctuations, hostile governments, global warming, overall availability of oil (peak oil), and the capital "lost" on import spending. Locally produced biofuels could create local jobs and keep revenues in the community. Biofuels would also take advantage of local resources, strengthen agricultural communities, and help the people of Hawaiʻi become more sustainable by diversifying energy sources and reducing GHG emissions.

Hesitation among respondents in regards to the use of bioenergy can largely be attributed to the lack of information about biofuel production yields, profitability, end-use requirements, and externalities. Because so much is not known about the future of biofuels, many respondents were reluctant to view biofuels as a dependable energy source without further information. The lack of reliable technology in production and conversion processes was also mentioned as an area that required clarification.

PART IV: Conclusions and Recommendations

Hawai‘i is currently in a unique situation due to its isolation and acute dependence on petroleum, despite an abundance of renewable energy resources, including solar, wind, geothermal, wave, and the potential for bioenergy crops. The State and private companies have taken serious interest in producing bioenergy in Hāmākua primarily due to its long agricultural history, land mass, and readiness of eucalyptus trees. Biofuels could be part of the solution to a number of problems facing Hawai‘i and Hāmākua, such as 1) reducing reliance on imported fossil fuels; 2) loss of agricultural businesses and lands; and 3) lack of local jobs in Hāmākua. In discussing if and how local biofuel production can address these concerns, decision-makers and community members need to keep in mind the existing situation—over 25,000 acres of eucalyptus is ready to be harvested in Hāmākua and Ka‘ū, over 14,000 acres of which is on Kamehameha Schools land in Hāmākua.

Biofuels have a Place in Hawai‘i's Energy Future

Recent government policies and public-private partnerships show that Hawai‘i is taking steps toward increasing renewable energy production. Most government policies support numerous renewable energy technologies, which imply that biofuels are only a part of the State's move toward expanding the use of renewable sources. Solar and wind are already commonly used power sources in local agricultural production, so familiarity makes these technologies likely candidates for expanded use. However, both are intermittent power sources and therefore their use is limited since the current energy system is fundamentally based on firm resources.

Considering the push to develop a Hawai‘i Bioenergy Master Plan, State government officials believe that the exploration of biofuels is in Hawai‘i's best interest. As legislation relating to biofuels unfolds at the federal and state levels, decision are being made on how biofuels can fit into a renewable energy future.

As renewable energy technologies improve, the desirability of certain sources of energy may change. For instance, if storage for solar and wind power improves, intermittency may become less of an issue. The current lack of connectivity between each island's electrical grids also means that each island must be self-reliant for electricity. The development of an undersea cable to transport wind-generated electricity to O‘ahu may increase grid resiliency. Developing an undersea cable may resolve the problem of intermittent power caused by many renewable power sources, in addition to providing power to the urban core of O‘ahu.

Technology within the biofuels industry is also improving. Second-generation biofuel conversion technology is currently being researched feverishly with government support, but it is unknown how long it will be until it reaches commercial scale. There is understandable concern that committing to a particular biofuel feedstock now means committing to a conversion technology that may rapidly become outdated. HECO and HELCO's pledge to use alternative energy and their need to meet a more stringent renewable portfolio standard (RPS) reduce some of the uncertainty regarding biofuel business ventures (HECO, 2008).

Feedstock Options and Conversion Processes are Interdependent

Regardless of the current eucalyptus plantation in Hāmākua, many feedstocks could be considered after the first eucalyptus rotation is harvested to ensure that the biofuel industry is producing the most energy possible per acre. Ideally, feedstock crops would produce high biomass yields with minimal chemical input and irrigation. Some feedstocks, such as eucalyptus, can produce high yields in areas with limited nutrients and at high elevations. Perennial grass species, like banagrass and guinea grass, are high yielding feedstock options that require little to no irrigation. Some feedstock options, such a leucaena, are also nitrogen-fixing and can be beneficial to soil conditions. Still other feedstock options—such as sugar cane, oil palm, jatropha, and kukui—may require chemical inputs or irrigation, but are known to produce high levels of oil for biodiesel or sugar for ethanol. No species is perfectly ideal, thus concerns about specific feedstock traits can be mitigated by selecting the species most suited to the characteristics of a certain site, intercropping, and using a species with beneficial traits that could be obtained through genetic modifications.

Committing to a biofuel crop is difficult for both the community and potential biofuel producers. Both are hesitant to commit to a crop that could prove harmful to surrounding ecosystems, native or otherwise, and most biofuel species are highly invasive (Buddenhagen et al., 2009). The same attributes that make these species attractive for biofuel production—rapid growth rate, low nutrient and water requirements, and ease of establishment—make them potential threats to surrounding ecosystems. One option to mitigate concerns about invasiveness is to require biofuel producers to fund or conduct invasive species control (Buddenhagen et al., 2009).

The choice of conversion process also presents its tradeoffs. Several commercially viable options were presented in Section 2.2 and each carries potential environmental and social impacts. Once built, changing a conversion plant is extremely costly. Stakeholders involved need to be aware of all the possible negative consequences during the project planning of any proposed plant in order to request mitigation measures or consider alternative proposals.

Environmental Impact Depends on Management Practices

Decision-makers may use GHG emissions as a way to measure the environmental impact of a biofuel industry. Though a net energy analysis or life-cycle approach to GHG emissions accounting for biofuels in Hāmākua is outside the scope of this study, it is important for decision-makers and producers to understand that GHG emissions vary with production practices and conversion methods. This is because fossil fuels currently power all levels of the biofuel production chain, and different crops and conversion processes have different energy yields.

Many of the *Eucalyptus* species already planted in Hāmākua have been identified as invasive. In addition, other potential biofuel crops identified within this study, such as *Leucaena*, are also invasive. Thus constant and proper management plans are necessary. This includes plans for management while in production and well-designed and executed plans for eradication if necessary in the future. Any business proposal for biofuel production should also contain an environmental management plan and should be made known through the Environmental Review process.

Agricultural Land Use Decisions that Balance Divergent Community Concerns

Since land is limited in Hawai‘i, land use and availability is a particularly important issue for agricultural production. Land use in Hāmākua centers on three concerns: preserving pastoral landscape, food production, and job creation. These concerns are not necessarily mutually exclusive—for instance, individuals that want more local jobs can still care about maintaining food production.

Hāmākua’s agricultural past, condition of the former sugar cane lands, and existence of large landowners, may allow the region to readily return to plantation agriculture. Nonetheless, a faction of the Hāmākua community wants to preserve the region’s pastoral setting. New homes and communities have developed since the close of the sugar plantations and newer residents may not be accustomed to or comfortable with the day-to-day operations of the agricultural industry.

Some community members are concerned that Hawai‘i imports 85 percent of our food (Office of the Governor, 2008). A new biofuel industry in Hāmākua has the potential to compete with the expansion of food production, which could ensure a more secure food supply. Given these points of contention, community members may benefit from having a forum to express concerns around the environment, food production, and job creation. In any case, the County or State may promote environmentally conscientious agriculture as one means of mitigating negative effects of agricultural production in the area.

Lease Terms Can Affect Industry and Environmental Outcomes

The future of biofuel production in Hāmākua then depends largely on how the region’s large landowners—the State, DHHL, Parker Ranch, Kamehameha Schools, and Kūka‘iau Ranch—choose to use or lease their lands. Following community outcry over leasing state lands for biofuel production, biofuel companies will need to look elsewhere to avoid displacing current lessees on state lands. There are almost 14,000 acres of eucalyptus trees that are ready for harvest on Kamehameha Schools land under lease to GMO LLC until 2020. Parker Ranch and Kūka‘iau Ranch have initiated experimental eucalyptus plantings on their lands. There is a program to convert invasive gorse on DHHL lands in Humuula into biofuel. Since DHHL has been seeking to generate revenue, they may be open to leasing their other Hāmākua lands for biofuel production. To produce biofuel feedstock on other private lands, biofuel companies will need to secure leases from private landowners, such as Parker Ranch or Kūka‘iau Ranch.

Long-term leases are potentially better for 1) industry development by providing more security; 2) the environment by encouraging more investment into land stewardship; and 3) the community by preserving rural characteristics. Businesses prefer these types of leases because it allows for long-range planning, investment into more efficient production practices, and participation in federal cost-share programs. Longer leases are a greater financial investment, so producers are more likely to take measures to reduce erosion and maintain soil health. From the community perspective, biofuel production in the Hāmākua region could prevent some land from being converted to urban uses. This is a concern that is not only prevalent in the Hāmākua community, but throughout the State.

While short leases are a problem for business planning, extremely long leases can also be a problem. Part of the reason the Hāmākua community was upset about references to potential 100-year leases on new lands was that tying up the land in such a long leases imposes a high opportunity cost for other alternative land uses.

As a compromise, landowners could consider offering mid-term leases for agriculture purposes, both biofuels and food.

The community may benefit from a combination of outreach to inform interested parties about available land, educational programs to train potential and existing farmers and producers, policies to specify the most desired types of agricultural production on IAL, and support for farmers or producers to establish operations.

Identity is Important

In addition to business plans and leasing lands, biofuel production will need to address issues surrounding community identity and process. Biofuel production on Hāmākua’s agricultural lands has the potential to fulfill the desire to keep agricultural lands in agricultural uses, while simultaneously providing jobs for local residents who are accustomed to agricultural industries. Regionally-located jobs would reduce commute times and increase quality of life for some long-time residents. However, business models will have to be aligned with how Hāmākua envisions itself and its future—Hāmākua has a rural lifestyle that residents and businesses we spoke with have a desire to perpetuate.

Hāmākua’s identity can be thought of as rooted in a sense of place, patterns of daily life, and a connection to the history of the land. This rural identity shapes both how individuals characterize themselves and what they want for the community. As a result, those seeking to introduce biofuels into Hāmākua should take care to understand how their businesses would influence not only socio-economic factors such as employment but how their production will affect the community’s way of life and identity.

In Hāmākua, agriculture is a prominent factor in self-identification as a rural community. The plantation system has left an indelible impression on the residents of Hāmākua. Some of those interviewed praise it for the benefits the industry provided and mourn its demise. Others interviewed denounce it for relying on a paternalistic business model, institutionalizing racism, and degrading the environment.

For many people, the plantation system serves as baseline information and influences their perceptions of the various proposed biofuel projects. When discussing biofuel projects, clarification of how the new business model is distinct from the plantation system could focus discussions on how a biofuel industry would look in contemporary Hāmākua. That agriculture is often synonymous with food production is a given, so thinking about biomass to energy may require a paradigm shift. Coupled with open, honest communication about known and predicted information, businesses, residents, and the government could expedite a confident decision making process.

Along with agriculture, ranching is a prominent land use for Hāmākua’s extensive acreage. Ranching is deeply rooted in Hāmākua, and has been practiced there since before the sugar plantations. While other more profitable land uses may exist, residents are still supportive of its continued presence. Current efforts to expand ranching and increase its profitability focus on promoting grass-finished beef and sustainable animal husbandry. Biofuel production can be synergistic with ranching if silvopasture is utilized, which can also reduce the competition for land and leases.

The Process is Important

Giving the Community a Voice

The concerns surrounding business plans, conversion processes, commitment of leases and identity, in the end, come back to the community. Dialogue needs to occur to find the common ground between maintaining a desired rural lifestyle and creating opportunities for gainful employment in the region. To the biofuels producers’ and community leaders’ credit, with the exception of rather rushed discussions on potential leasing of State lands, the biofuels process has been relatively transparent. However, even though the public has been provided with various presentations on the science and scope of the projects, as well as lengthy question and answer sessions, it is still unclear how community interests and concerns will be incorporated into future decision-making. This is in part due to the general uncertainty about the industry, both in terms of economic viability and environmental impacts.

The community needs to have a way to meaningfully participate in shaping the future of Hāmākua. The term “meaningful participation,” however, is often hard to define, and varies on a case-by-case basis. While it would be ideal if the Hāmākua community were able to participate fully, it must be acknowledged that participatory processes are often lengthy, costly and difficult to scale. This begs another question regarding the meaning and boundaries of community; does community include those who live, work and play in Hāmākua? What about those who have recently moved there, or those who visit Hāmākua? These questions are difficult to answer and must be weighed carefully by those proposing projects and plans. At the very least, anyone who is capable of blocking a decision from being implemented should be included. Those who are directly affected by proposed plans should also be invited to participate and voice their concerns.

Despite the ambiguities and challenges associated with community participation, the community wants a transparent process, clear and direct answers to their questions or concerns, and the confidence that biofuel producers are listening, so biofuel plans can align with the community's interests, needs, and concerns. This collaboration between producers and community will increase transparency and trust, while ensuring that adverse impacts of new projects are minimized while benefits are realized for the community.

Empowering the Community through the CDP Process

The Hawai‘i County district-based CDP process is an excellent vehicle to empower the community and provide a forum for better communication. The current Hawai‘i County General Plan, approved in 2005 by the County Council, is the overall planning document for Hawai‘i Island. This General Plan mandates County districts to plan for the future through implementation of CDPs (HCRC, 2009). CDPs are intended to:

> Translate broad General Plan goals, policies, and standards into implementation actions as they apply to specific geographical regions around the island. CDPs are also intended to serve as a forum for community input into land-use, delivery of government services and any other matters relating to the planning area. (HCRC, 2009, p.1)

Five other communities on Hawai‘i Island—Puna, Ka‘ū, Kona, North Kohala, and South Kohala—have completed or are underway in the CDP process, and informational meetings have already been held for Hāmākua (Hawai‘i County Resource Center, 2009). The Kona CDP, completed in 2008, includes a community vision statement and guiding principles for areas such as land use, transportation, environmental resources, cultural resources, energy, economic development, housing, and public infrastructure, facilities and services (Hawai‘i County Resource Center, 2009).

By modeling the Hāmākua CDP similar to the Kona CDP, the Hāmākua community would be able to address many of the issues that have surfaced during the biofuels proposal process. Through a visioning process, the conflicting value statements expressed during our interviews and in public meetings could be deliberated and reframed into a coherent vision of Hāmākua that everyone can tolerate. Guiding principles can help to address community concerns about environmental management, lifestyle impacts, existing industries, and agricultural expansion. Additionally, as learned from the interview data, the Hāmākua CDP process will attempt to involve a representative sample of the community that mirrors its demographic characteristics. This can help to resolve some of the issues regarding the definition and boundaries of community.

The CDP provides Hāmākua the opportunity to collectively plan its community before someone else does. The relevance of this process extends beyond the potential for, and desirability of biofuel production. It will allow the community to provide significant and meaningful input into determining the future of Hāmākua. Already, some businesses have decided to hold off on their plan implementation until the CDP process is complete. Hāmākua should take advantage of the

CDP and develop a unified vision and value framework that can guide vetting future development proposals, including biofuels.

Final Thoughts

There are many unknowns about biofuels, and therefore the risks and impacts associated with producing biofuels in Hāmākua are not perfectly clear. This makes it difficult to confidently commit land and other resources to biofuels. A decision, though, is required whether to dedicate only the existing trees to a potential biofuel industry or to allow more lands to be put into biofuel production. Hāmākua could potentially benefit from increased economic development and biofuels may be a way to provide this while perpetuating the rural, agricultural identity of Hāmākua. There is also general agreement on the need for increased use and production of renewable energy and less reliance on fossil fuels. Biofuels should be considered as a potential component of the State's plan to move toward a cleaner energy future. Using the CDP process or other means, Hāmākua community members should have a serious, open, and respectful deliberation about the future of their community and how biofuels might fit into that vision. This is the only way to ensure that an opportunity is not lost and mold it into something that everyone in the community can live with.

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APPENDICES

Appendix I. Current Biofuel-Related Companies in Hawai‘i

HĀMĀKUA

Sun Fuels
Biomass to Liquid Technology
Research and development phase
www.choren.com/de/

Haina Hawaiian Hardwood
www.woodfromhawaii.com

Tradewinds Forest Products
www.tradewindsForestproducts.com

Fuel Alternatives Pacific, LLC

Hū Honua Bioenergy
www.huhonua.com

Hāmākua Biomass

KONA

HR Petroleum
www.hrbp.com/

Kai Bio Energy Corps
www.kaibioenergy.com

MAUI

Pacific Biodiesel
www.biodiesel.com

Blue Earth Biofuels
www.blueearthbiofuels.com

Appendix II. Survey Methodology and Questions

To gather information on biofuels, both generally and specific to Hāmākua, three surveys were created and tailored to scholars and experts, agricultural producers, and current/potential energy producers. Survey questions ranged from issues of species selection and best management practices, to community sentiment and sense of urgency toward the use of biofuel. Additional questions were developed depending on the interviewees area of expertise. Interview questions are summarized below.

Scholars and Experts

1. Do you think biofuels are a feasible energy solution for Hawai‘i in the areas of electricity and transportation? What are the best alternatives to biofuels?

2. Are there tradeoffs, opportunity costs, and/or barriers associated with biofuels? If so what are they?

3. Is there a market for biofuels in Hawai‘i? If so, what is the market?

4. Biofuels can be produced from a wide variety of inputs and species and require conversion processes. Please list, to the best of your knowledge, what you feel are the ideal species and conversion processes. Are there “best practices” regarding these species and processing?

5. There are several potential sites for biofuel production in Hawai‘i. Do you think Hāmākua is a good site for biofuel production? What are the best types of land for biofuel production?

6. What could the potential consequences and impacts of biofuel production be on (1) environmental health and (2) the local community?

7. What is the best use for currently fallow agricultural lands?

8. Assuming we are on the path for widespread biofuel use, what is your idea of the end-vision and how would you measure future successes?

9. How do you feel about using government funding or resources for biofuels production? Do current policies allow for the streamlining of processes to start a biofuel production operation? Do they adequately address concerns about negative potential outcomes?

10. On a scale of 1-10, 10 being the highest, how would you rate your sense of urgency in using biofuels to addressing Hawai‘i’s current energy situation? Why?

11. Do you have any suggestions for other people we should interview to further our knowledge about the subject?

Agricultural Businesses

1. What kind of crop/livestock does your operation produce? What motivates your crop choice? How much of a role does profit play in your crop selection?

2. What is the current primary market for your crop? How much of your crop is sold locally (on island)?

3. How many acres are you using? Do you own or lease? If you lease, who is the owner and how long is your lease?

4. How much water does your operation require in an average month? Source?

5. How many workers do you employ, including yourself and your family?

6. Some lands in Hāmākua have been proposed for biofuel production. Do you think this is the best use for these lands? If not, what might be a better use?

7. What are your top three (3) concerns about biofuel production in Hāmākua? What do you think are the community's top concerns?

8. What is the best end use of Hāmākua-produced biofuels: electricity or transportation?

9. Do you, or are you planning to, integrate renewable energy technology into your operation? Would you consider using biofuel? Do you see any benefits in subleasing part of your property for co-production with a bioenergy company?

10. How organized is the agricultural community in Hāmākua? Are there active co-ops in the area? Do you participate in a co-op? Please describe your participation in the agricultural community – i.e. associations, farmers' markets.

11. Do you think there will be community benefits from the biofuel companies? What kind of benefits would you like?

12. How do you see Hawai‘i Island in relationship to the other islands, economically and/or socially?

13. How do you envision the future of agriculture in Hawai‘i? How does your operation fit into that vision of the future?

14. Are there other people or key community members we should talk to? Any other comments?

15. On a scale of 1-10, 10 being the highest, how would you rate your sense of urgency needed in using bioenergy in addressing the current energy situation? Why?

Energy Businesses

1. What is the best end use of Hāmākua-produced biofuels: electricity or transportation?

2. Is there a specific biofuel crop or crops that you think would be best for Hāmākua? Why?

3. Do you plan for mixed use on your bioenergy production land? Would you consider integrating other types of renewable energy sources into your operation?

4. How much land does your operation require? Do you own or are you interested in specific areas?

5. What conversion process(es) do you plan to use? What are your expected outputs? How much energy will your operation produce in relation to local demand?

6. What other inputs does your operation require? What type of infrastructure? Who will provide the infrastructure?

7. What will be the byproducts of your operation? Do you have a plan to use any byproducts?

8. When is your product expected to be market ready? Will your biofuel be used locally? Who will your buyers or potential buyers be?

9. How do you see Hawai‘i Island in relationship to the other islands, economically or socially?

10. What are your top three (3) concerns about biofuel production in Hāmākua? What do you think are the community’s top concerns?

11. How will your operation benefit the Hāmākua community? For example, how many jobs will be created?

12. Are there other people or key community members we should talk to? Any other comments?

13. On a scale of 1-10, 10 being the highest, how would you rate your sense of urgency needed in using bioenergy in addressing the current energy situation? Why?

Additional Questions

1. How do biofuel plans relate to local, county, and state development plans? Where are the decision points for public interaction in current plans and planning processes relating to bioenergy production?

2. Do you think there will be community benefits from biofuel companies? What kind of benefits would you like?

3. How have industries or attempted projects affected the community in the past?

4. What is the appropriate scale for biofuel or biomass production in Hāmākua?

5. Do you think silvopasture is a possibility for biomass production? Are there other possibilities of value-added products?

6. What do you see as the major obstacles in the modeling or determining the profitability of biofuel production for Hawai‘i? Where is the data most lacking?

7. What effect(s), if any, did the sugar industry have on the soil and ecology of the Hāmākua area?

Appendix III. Detailed Survey Responses

To better understand the technical, environmental, social, and policy issues surrounding biofuels, particularly in the Hāmākua region, this study interviewed 54 people falling into the categories of 1) experts in energy, forestry, agriculture, and environmental management; 2) business leaders in forestry and energy; 3) business leaders in diversified agriculture, cattle ranching, and dairy farming; and 4) public officials and public employees in the areas of energy, water, and community planning.

The format of the interviews was an informal discussion constructed around a general survey instrument (see Appendix II). Detailed notes were taken—both typed and hand-written. The following summaries are provided to give a more detailed overview of the reactions and answers of the interviewees to the survey questions.

Because the impetus for this study revolves around a question of urgency for biofuels, the following question is addressed first as an overarching factor

Summation of all respondents' answers to the following question:
On a scale of 1-10, 10 being the highest, how would you rate your sense of urgency needed in using bioenergy in addressing current energy situation?

Of the respondents who answered with a specific number, about one in four people felt that the urgency was a 10. 86% of our interviewees felt that the urgency level was a 5 or above, and those who did not rank it a 5 or above often ranked it a one, sometimes asking if a negative number could be used.

On average, participants ranked their urgency as a 7.0. Almost half of the people mentioned that research to further develop alternative forms of is important in general; most people felt that biofuels should be included in this mix, while those who responded with low levels of urgency felt that biofuels should not be focused on as a renewable energy because of their preference for other alternative energy sources. Many of those who thought that bioenergy use is urgent felt that it is just a part of a renewable energy future, especially because of its ability to provide a liquid fuel.

Many respondents felt that Hawai‘i needs to lessen its dependence on fossil fuels—citing the price fluctuations, hostile governments, global warming, potential transportation reliance issues, overall availability of oil (peak oil), and removal of revenue from the local market. Locally produced biofuels would create local jobs, and keep money in the community. It would also take advantage of the local resources that Hawai‘i already has, which would help strengthen agricultural communities and help the people of Hawai‘i become more sustainable.

Hesitation in the use of bioenergy can largely be attributed to the lack of information about biofuel production yields, profitability, end-use requirements, and externalities. Because so much is not known about the future of biofuels, many respondents were reluctant to view biofuels as a dependable energy source without further information. The lack of reliable technology in production and conversion processes was also mentioned as an area that required attention.

Despite answering the question with respect to the current energy situation, some respondents did not think that energy is an important issue overall. Specifically mentioning that energy reliance is not an urgent problem compared to other societal ills and thus found the question to be irrelevant. This polarization was found throughout the interviews with various participants from all sectors. People either found Hawai‘i's energy situation to be a pressing matter that needs to be addressed, or are not concerned with the energy situation because other issues are more urgent and important. Thus, the ranking of urgency in response to the question does not necessarily relate to the overall urgency of biofuel use for society, rather the ranking is solely relative to Hawai‘i's current energy situation, which is not necessarily a matter that needs to be urgently addressed.

I. ***Experts: Energy, Forestry, Agriculture and Environmental Management***

1. Do you think biofuels are a feasible energy solution for Hawai‘i in the areas of electricity and transportation? What are the best alternatives to biofuels?

Almost all of our participants agreed that biofuels can be a part of the future energy mix in Hawai‘i, under certain conditions. The adoption of biofuels for use in Hawai‘i depends on (in order of number of times mentioned): economic feasibility, technological advancements of current biofuel production technology, the best use of the land, environmental health, cultural/community acceptance, the price of oil, and alternative energy costs. All of the conditions were mentioned by at least two of our interviewees.

There are many types of biofuels, and they may not all be a part of the energy solution. The time frame for which biofuels are or will be used differs depending on the type of conversion methods being considered. According to one respondent, burning biomass waste products for electricity is and has been done in the past, biodiesel from used cooking oils is currently sold, and biodiesel from crops is seen as arriving in 10 years. Additionally, the different characteristics of the various islands in terms of environment, available alternative energies, and energy demands may make specific types of biofuels more attractive for some areas than others.

Another major theme regarding the feasibility of biofuels mentioned by a few of our interviewees is the debate between food and fuel production. These interviewees would like to see locally produced food before seeing locally produced fuel. Points raised to support this viewpoint include: food crops tend to have higher value (thus making farmers more money), and food can be more expensive to ship than fuels. One interviewee also brought up an interesting complexity in the food verses fuel debate, as all large-scale agriculture is heavily mechanized, using vehicles and machinery that requires fuel. Thus agricultural production can be heavily dependent upon fossil fuel, making food security and energy security linked since energy is needed to produce food.

In terms of using biofuels for transportation versus for electricity generation, some scholars responded that one of the two end-uses is feasible, while some thought both are feasible options:

- Those who thought biofuels would be good for transportation supported their choice citing Hawai‘i’s large demand for liquid transportation fuel (and a lack of other renewable forms of liquid transportation fuels), and the higher efficiency of using biofuels for transportation. Biodiesel was specifically mentioned because of the large amounts of boats and trucks in Hawai‘i that could utilize the fuel.

- Those in favor of electricity generation pointed out that local energy providers (HECO, HELCO) are already been looking to biofuels, since they fit into the current structure of electricity generation and distribution more easily. Some stated that they favor electricity generation as byproduct of some higher-value production, thus using waste as biofuel.

Wind (and wind combined with pump-hydro storage), geothermal, and photovoltaic energy generation were equally and most frequently mentioned as the best alternatives for renewable energy. Other alternatives mentioned were wave and tidal electricity generation and ocean thermal energy conversion. It should also be noted that the interviewees felt biofuels are attractive because of their ability to provide firm power, which some other renewable energies cannot claim.

2. Are there tradeoffs, opportunity costs, and/or barriers associated with biofuels? If so, what are they?

Tradeoffs, opportunity costs, and barriers can be grouped into three main areas of concern:

- Location barriers: getting long-term leases for land, the high cost of land, permitting and site location for bio-refineries, and issues with the transportation of biomass and biofuels (road limitations and dangers, and port limitations).

  Specifically addressing tradeoffs between scale of the biomass production operation: for large-scale production, which is more profitable and required for the amount of energy that of the potential plants want to produce, land is not always contiguous. Small-scale operations would need to be in close proximity to reduce transportation costs to processing and conversion sites, and operations may not be as efficient as large-scale operations. Communities may be opposed to large-scale operations due to the previous ills of the large-scale plantations.

- Species and inputs issues: inputs are expensive, water is expensive and not available, irrigation systems are not available or inadequate, and some feedstock species are listed as invasive and thus must be tested or altered genetically. Many interviewees stressed that there was a lack of research and available data to make informed decisions. There needs to be more data about the plants themselves, and about site climates, so yields and environmental impacts can be projected and estimated. Specifically, information about species performance in Hawai‘i is lacking because information from other climates or regions does not usually apply to Hawai‘i’s unique growing conditions.

- Community issues: food versus fuel, community support, labor availability, farmer willingness to (1) continue farming, and (2) plant biofuels, environmental degradation (especially that from large-scale agriculture), aversion to monocropping (if monocropping is the method of biomass production).

Many participants mentioned that yields in Hawai‘i are much higher than in other places because of the year-round growing season and available water, which can offset potential downsides to biofuel production. Also, the large amount of money that leaves the state because of our oil dependency could dramatically change our communities if invested here.

3. Is there a market for biofuels in Hawai‘i? If so, what is the market?

Many respondents felt there is a market for locally produced biofuels, given that it is competitive with fossil fuels. This can be achieved, but is dependent upon various (mostly unpredictable) factors, such as the price of oil, government support for biofuels through direct subsidies or taxation of fossil fuels, the potential for carbon credit trading, and local consumers' willingness to pay more for locally-grown renewable sources.

Both electricity generation and liquid fuels for transportation were singled-out specifically as individual markets for biofuels. Some scholars suggested that depending on the future of transportation, liquid fuels will at least be needed during the transition period to electricity or hydrogen. Biofuels are diverse enough to be used in different types of transportation vehicles, including aviation, automobile, and vessel fuels, expanding their potential market. Scholars also mentioned that on-farm generation is a good use for biomass or biofuels, as it would be considered a coproduct, and could utilize on-site materials that are currently considered. Some interviewees clearly stated that biofuels are just a part of the future energy market, echoing their responses to the feasibility of biofuels question (#1). Some specifics about the market were mentioned: one company, Pacific Biodiesel, is in the business of producing biofuels locally; the mandate of ethanol blending in gasoline has caused interest in ethanol plants—MECO and HECO have planned for plants fueled by biofuels.

4. Biofuels can be produced from a wide variety of inputs and species and require conversion processes. Please list, to the best of your knowledge, what you feel are the ideal species and conversion processes. Are there "best practices" regarding these species and processing?

Our respondents agree that there is not a single ideal species for biofuel production. Site-specific parameters like rainfall, irrigation, slope, soil type, harvest requirements, and accessibility are all part of species selection. The length of the land lease and ownership of the land is also an issue in species selection, because some crops require long commitments to the land. Management practices for inputs are site-specific and need to be developed for each site and species combination selected. Reduced or no-till agriculture was mentioned, as was proper fertilizer use, and prohibiting clear-cutting or leaving soil bare. Another part of species selection is dealing with the potential invasiveness of species.

Some respondents have an interest in perennial crops because of they are lower in maintenance costs; however they often have a lag time before producing revenue. Native crops were mentioned for their cultural value and their acceptance. Tree crops can tie up the land for a long period of time, which can protect the land but attach producer and landowner to their decision despite advancements in research and technology. Annual crops grow fast and can have high yields but required inputs are higher than in perennials.

Some species mentioned include:

- Jatropha, which is considered invasive and toxic. It is drought tolerant, and no one really knows the true yields, but it could be highly productive. Also, harvesting is currently done by hand; there are no mechanical harvesting machines.

- Oil palm was also mentioned by multiple respondents, specifically because of its high oil yield, and genetic strains that could be easier to harvest. Oil palm production may have other higher-value or socondary products than just biofuel. Oil palm has a higher water requirement than Jatropha.

- Some researchers mentioned Energy cane. They feel it is a possibility, because Hawai'i is well suited to sugar cane growth, the knowledge for sugar cane growth is here.

- Pongamia, another nitrogen fixer (in addition to Jatropha) was also mentioned. In general, nitrogen-fixing plants reduce the amount of fertilizers necessary because they are capable of supplying their own nitrogen.

- Moringa, kamani, kalamungai bean were also mentioned.

- Other grasses (besides sugarcane) like rapier grass, banagrass, and guinea grass, were all mentioned.

- Kukui was also mentioned; it takes a long time to develop (before yielding fruit). Also, because it is valued for its oils in specialty markets, energy co-production is a possibility

- Algae (many different species both salt water and fresh water), and the potential for its use as a biodiesel source was brought up. Though algae technology is largely proprietary, should conversion technologies become advanced enough, there is a potential in terms of yield and production efficiency. Extraction issues are problematic because drying is energy intensive.

Because conversion technologies are evolving and on such a large scale (fisher trophic conversion, pyrolysis, gasification) there is not enough information to fully understand which will be best. It again depends on the economics of the production and the type of fuel needed. Also, siting again plays a role in this, among other issues, because processing and conversion plants need to be appropriately placed to limit transportation (of biomass to processing and conversion) costs.

Another recurring theme was the desire to use leftover biomass for biofuel production, and use the higher value items in their markets, for example: kukui oil could be used as a high-value oil and the byproducts (remaining biomass) for electricity, offcuts from a veneer plant could be used for electricity generation. This makes biofuel or electricity production from biomass a secondary product, adding value to the production of the plant.

5. There are several potential sites for biofuel production in Hawai'i. Do you think Hāmākua is a good site for biofuel production? What are the best types of land for biofuels production?

Most scholars agree that Hāmākua is a good site because of adequate rainfall, good sunlight, good climate—overall good growing conditions. Things grow rapidly, which means it is a good place to grow a lot of things, including food and cattle. Hāmākua has a lot of available land, which also makes it ideal. Hawai'i in general is ideal because of the year-round growing season, allowing for maximum biomass production.

Some people have concerns about Hāmākua as a site; they mentioned that it has some elevation changes, making species selection difficult. The variation in historical land management has lead to different growing conditions based not only on natural factors, but also on historical factors. Topography—there are deep gullies that run mauka to makai—requires fields to be narrow, increases erosion, and increases harvesting costs.

There was some disagreement over suitable lands for biofuel production in Hāmākua. Because it is such a good site for agricultural production, some scholars felt that Hāmākua is best left to food and diversified agricultural production, and marginal lands should be used for biofuel production, even speculating that for farmers on prime agricultural land, it may be more profitable to grow food crops. Other participants disagreed with this and want to leave marginal lands as a last resort (one that is not necessary because there are other, more suitable lands). Another group of scholars felt that available land should be put into production, and if it is not used for food, it can be used for biofuel. In Hāmākua, monocrops like sugar have already been grown and proven to be unsuccessful.

Some scholars mentioned that a mixed use of the land for the production of multiple products is ideal, for example tree crops and grazing; however, there is an issue with efficiency, as separate uses may be more efficient then mixed use. Also, the supply chain for the multiple products would need to be developed in Hāmākua, or for any site dealing with multiple products.

6. What is the best use of currently fallow agricultural lands?

Opinions for fallow lands differ, but ultimately, there is no one best use; it depends on the needs of the state and the community. Some scholars also mentioned that the accessibility of the lands should also help dictate the future use, as those with roads and structures already in place are better suited for production.

Suggestions include: use it to grow something—grasses, trees, cattle or other protein, truck crops. Some land can be used for conservation or sustainable forestry—this would depend on the land and the community. Diversified agriculture could be a good use. Unfortunately, people do not seem to have plans to grow any food on available open lands—there is no one to farm it. Forestry could sequester carbon, if land is available, given forestry usually requires a large-scale operation in order to be profitable. In some cases, wise growth (residential areas) can be the best use, but the best agricultural lands that have gone fallow should stay in agriculture. Leaving fallow land unmanaged can create a bigger issue as it will consequently be overrun with invasive species—this is largely an issue with former large-scale agriculture land—thus some managed use is preferred.

7. What could the potential consequences and impact of biofuels production be on environmental health and the local community? What are your top 3 concerns?

Pros (if a biofuel operation is managed properly): jobs—a sustainable producer with long-term jobs would be ideal, also training and job skills and local production for local use, community independence (especially if biofuels have a developed industry with coproducts). There is also the potential for good land management, which is better than no management—this could lead to potential decreases in soil erosion and increases carbon sequestration.

Cons: Traffic, fumes, noise, water use. Other negatives if the biomass production is not well managed: potential soil degradation affecting future production capabilities, clean air, clean water. The ills of the sugar industry/monocropping: agricultural runoff with pesticides and chemicals. If an invasive species is used as the feedstock, potential escape of an invasive species. Large-scale potential loss of biodiversity. Because of interspersed gentleman's farms—fire risk. Land is an integrated system—lower lands are dependent on forest above—so land management can have a negative outcome on nearby lands.

Fortunately for our community, many scholars stated that community support is key: if there is no community support there will not be action. Unfortunately, the definition of the community is a key issue that needs to be resolved.

8. Assuming we are on the path for widespread biofuel use, what is your idea of the end vision and how would you measure future successes?

End-visions often included sustainability, as it was mentioned by almost all of our respondents. Specifically, environment and ecosystem health, economic longevity, creating long term jobs with livable wages, and sustainable water use and availability were all mentioned. Lowering the cost of living in Hawai‘i was also mentioned by a few people. The development of secondary markets for the biomass (beyond fuel), which would help to ensure long-term success of the agricultural production of biomass, was a suggested. Also, increased food security was also discussed as a part of the end-vision for successful biofuels.

Indicators for future success include: biomass production productivity (in terms of profit/yield) and profitability, stability (to resist feast and famine), resiliency (capable of withstanding environmental and economic stress), equitability, and adaptability. Also, community health and support, employment increase with increase in sustainable production of biofuels (not just a displacement of jobs), reduction in the amount of fossil fuels imported, and lower energy costs, were all mentioned as measureable indicators.

9. How do you feel about using government funding or resources for biofuels production? Do current policies allow for the streamlining of processes to start a biofuel production operation? Do they adequately address concerns about negative potential outcomes?

Government funding was broken into two areas by our respondents—market support and research support—and was also broadened to include governmental policies that could support or oppose biofuels.

Most scholars are not in favor of government funding in the form of subsidies and taxes because of improper pricing and market distortions. There are many alternatives to biofuels, thus the government should not bias the market towards one source of renewable energy. One interviewee stated that government funding could be used as seed money for the industry, but should not last after the industry gets situated. Despite this sentiment, one interviewee pointed out that tax credits are already happening, and because the government has so much land, they could subsidize an industry just based on whom they allow to use the land.

Almost all of our respondents think the government should financially support biofuel research. Reasons for this include: the high risk of the research (that scares away private investors), the need for new techniques and technologies in the industry, the lack of information about biofuels, and misinformation or bad information that can lead to bad decisions. Thus research is necessary to make better decisions.

Policies should encourage longevity of biofuel production, and work for the best interest of the people. This could include setting precedence for the use of land, setting up policies for the market, and requiring the use of renewable energy. Government should also put values on essentials that are currently undervalued like clean air and water which would make clean energy will look more attractive. The examples of the mainland are not necessarily going to work for Hawai‘i, so local government needs to create policies with Hawai‘i in mind.

Loan programs and incentives were mentioned to aid in the start up of biofuel production because the start up of production is capital-heavy. Providing incentives use would aid in promoting biofuel production operations to private investors.

Many thought the current policies do not streamline biofuel production. In order to make the biofuel production permitting process more efficient, pre-designating areas for conversion sites could help make permitting easier for those operations. Hawai‘i is not known for being business friendly, thus some scrutiny of the regulation process should be altered to prevent the stifling of development, but not at the expense of the environment or community.

10. On a scale of 1-10, 10 being the highest, how would you rate your sense of urgency in using biofuels to addressing Hawai‘i’s current energy situation?

The answers given range from 1-10, with an average of 5.95. When ranked, the middle number is 6.25, and the most frequent response is 6.5.

Scholars stated that there is an urgent need for alternative energy, but not necessarily biofuels. Reasons for an overall energy urgency include peak oil (oil shortage, rise in oil price) and climate change. Hawai‘i’s need for self-sufficiency and locally produced products was also a reason for some urgency. Specifically for biofuels, those who were not on either extreme ranked biofuels in the middle because it is not the most urgent thing that we have to deal with, but it is important as part of the energy solution and part of the problems the state is facing. Middle-range score respondents cited the industry’s lack of knowledge and technology for making a sound decision, stating that more knowledge could lead to a better decision. One interviewee stated that as a country pursuing biofuels are important because competition with other countries for knowledge and resources is occurring.

II. *Business Leaders: Diversified Agriculture, Cattle Ranching, and Dairy Farming*

1. What kind of crop/livestock does your operation produce? What motivates your crop choice? How much of a role does profit play in your crop selection?

Respondents represented 12 agricultural operations – six ranches, including five cow-calf operations and one dairy, along with six diversified farms, including five specializing in niche edibles and ornamentals and one family farm. Most of the ranches have 1,400 to 15,000 head of cattle, and a few of the operations had other business ventures onsite, like hunting, land assets, and agro-tourism activities.

Profit plays a major part in crop selection for all diversified operations, except the family farm—profitability makes business operations sustainable. Compared to ranching, these low volume, high value niche products have a low cash outlay, so they can be more successful on a small scale. The cost and availability of labor keeps some of the diversified operations small—having fewer non-family workers helps to maintain profit margin. For some respondents, farming is also a personal lifestyle choice.

Profit is also the biggest driving factor for the ranching operations. Some ranches produce as much of their own inputs as possible, including guinea grass, and corn. One rancher felt that grass finishing is not the most efficient use of resources, but it plays into the local market and could be successful. The cost and availability of slaughter is a major economic crux for ranching operations. Two respondents noted a lack of efficient slaughterhouses on Hawai‘i Island. According to one, even in the 1980s when local ranches were producing all the meat in the State, it cost producers $100/head to kill and process, when it only cost $25/head on the mainland. Hawai‘i can produce calves, but there are not enough resources to produce the amount of grain needed to make local grain finishing economical. However, there is interested in developing ultimate markets—both cow-calf operations for the mainland and grass finished operations for Hawai‘i—to market in multiple areas of the country and in multiple climates.

2. What is the current primary market for your crop? How much of your crop is sold locally (on island)?

Three of the four cow-calf operations sell primarily to the mainland, where the cattle is finished. Locally finished cattle are grass-fed, which is gaining popularity according to the operations that are making that transition. With rising awareness about food miles, hormones, and antibiotics, consumers are looking to purchase local meat. Furthermore, rising transportation costs have made grass-finished beef more affordable. The diversified farms primarily serve the local market—some have even chosen to serve Hawai‘i Island first, then other islands. They depend on distribution through local grocery stores and restaurants. Two of the operations sell a majority of their merchandise from their properties, through either onsite restaurants or mail orders.

3. How many acres are you using? Do you own or lease? If you lease, who is the owner and how long is your lease?

The agricultural producers interviewed operate on 2.3 to 130,000 acre plots – most ranches ranged from 10,200 to 130,000 acres, with one 30-acre operation, and the diversified farms are on 2.3 to 35 acre plots. Most operations have a combination of owned and leased property. Respondents operate a total of 199,822 acres; 74,690 acres (37%) of which is leased. Leases ranged from 10 to 99 years; the shorter are from small private landholders, Hawai‘i County and the State of Hawai‘i Departments of Land & Natural Resources (DLNR) and Hawaiian Homelands (DHHL), and the longest leases are through Kamehameha Schools (KS).

4. How much water does your operation require in an average month? Source?

Four of the ranches use stream diversions, one uses well water, and one uses ditch water for irrigation. Six of the twelve operations depend partly on county water to supplement other irrigation sources, such as stream diversion and water catchment systems. The cattle operations use about ten gallons of water per head per day—that requires 1,500,000 to 6,000,000 gallons of water per month. The diversified farms use markedly less water for their operations—about 20,000 gallons per month, using less in the rainy season. Those operations closer to town depend on county water.

5. How many workers do you employ, including yourself and your family?

Operations employed 2 to 23 workers, including family members. The operations that include agro-tourism activities and other services have the most employees, and 10 of the operations employ only full-time workers.

A couple respondents made mention of utilizing WWOOFers—workers through the World Wide Opportunities on Organic Farms—but have opted not to use them because the workers do not stay long enough to make training worthwhile, nor do many operations have sufficient lodging.

6. Some lands in Hāmākua have been proposed for biofuel production. Do you think this is the best use for these lands? If not, what might be a better use?

Ten of the twelve interviewees felt that biofuel production, especially in the form of a eucalyptus monoculture, is not the best use for the land in Hāmākua. Reasons include: 1) lack of technology to make biofuels economical; 2) solar, wind and/or geothermal are more efficient uses of resources than biofuels; 3) the land is difficult to farm; 4) monoculture production is not sustainable or economical; 5) incoming companies may not be able to grow crop at a scale large enough to make biofuels economical. One respondent was unsure, but noted that Hāmākua has vast amounts of unfarmed agricultural land that would not require much irrigation.

Four of the respondents felt that some sort of food production, either cattle—including grass finished—or diversified agriculture, would be a better use of the area. Two respondents said that higher-value products should also be grown on the property—hardwoods, aquaculture products, native forest. After higher value products are made or harvested, the remaining biomass from forestry and/or agriculture could be burned for energy.

Two of the ranchers felt that if biofuel production does happen in Hāmākua, coproduction would be the best plan as long as 1) the community is involved in discussion about jobs, harvest practices, crop use, and energy; and 2) there is not a net loss of grazing land.

One of the respondents felt that there should be more direct biomass to energy production – several companies are proposing to do such a project, and no one else has a better idea, but not all of the land in Hāmākua should be used for biomass.

7. What are your top three concerns about biofuel production in Hāmākua? What do you think are the community's top concerns.
Note: typically respondents answered this question with three concerns total, which were a mix of both personal concerns and community concerns.

The top concern is that biofuels will not be economical because of fluctuating oil prices and lacking technology, infrastructure, market, and/or regulatory framework. Other responses included (in order of times mentioned):

- Replacing diversified agriculture and/or cattle ranching with biofuel production
- Jobs – lack of jobs created and types of jobs created
- Noise from harvesting and transporting biomass
- Use of trees – chip and burn may not be the best use
- Adequate planning to avoid short-sighted decisions – species choice, cultivation, harvesting, transportation, fire management
- Community will not be involved in the planning and/or implementation process
- Environmental stewardship – over-extraction of nutrients, soil erosion
- Dedicating industry to one major conglomerate
- Community will not benefit
- Over-regulation and public opposition
- Safety of workers and neighbors
- Conflict with crown/ceded lands on State property

Food is more important than fuel, and food security is dependent on farmers. Hawai'i needs to make agriculture economical in order to keep farms in business. Biofuels are not a bad investment, but depending on fuel from plants is like depending on a perpetual motion machine. It constantly needs inputs, like fertilizer.

Some interviewees also provided arguments against some of the common concerns they felt others could have:

Several responses indicated that Hawai'i has benefited tremendously from large landowners and sugar plantations, despite the community's recent skepticism of big agricultural companies. At the Hāmākua plantation, young workers were able to build full careers—the plantation took young people that could not read or write, and had them trained to operate machinery in a short amount of time. The community reaped benefits through employment, housing, medical treatment and infrastructure. Revenue from the plantation went toward the University, State buildings, the airport, water ditches, and roads.

On a similar note, Alexander & Baldwin (A&B) provided much of the infrastructure on Maui. Water systems that the plantation installed for housing and irrigation is now utilized by the county. Sugar production on A&B property also provides electricity from biomass to Maui Electric Company and Maui is the only island with two electrical grids. The two-grid system greatly reduced blackout time on Maui after Hurricane ‘Iniki in 1991. Just recently, A&B was the first landowner to declare a portion of their property as Important Agricultural Lands—they set aside 40,000 acres.

When asked about the use of genetically modified organisms (GMOs), one respondent expressed that misinformation has created resistance against something that may be beneficial, citing the GMO taro debate as an example. Researchers at the University of Hawai‘i wanted to investigate disease resistance on non-Hawaiian taro varieties, since taro farms in other areas of the world were failing. The Hawaiian community protested because they thought that the GMO varieties could cross-pollinate with the Hawaiian varieties. However, the 67 Hawaiian taro varieties are fairly pure because cross-pollination is complicated. Had protesters understood the science, they may have understood that GMO research could protect local poi production.

Additionally, the presence of GMO research in the islands can be seen as beneficial to some. In the last 10 years, Monsanto has expanded and now provides about 2,000 jobs and significant economic activity through GMO research. They support a lot of smaller farmers, bringing in larger quantities of farm equipment and chemicals, so that small farmers get a better price. GMO means research and jobs, and can reduce the amount of chemicals used.

The source of funding for biofuels also came up in discussions. Some respondents felt that government funding is necessary because until a system or species is found profitable, it is difficult to do research through a private company. One respondent felt that it was acceptable to use government money to fund biofuel research, as long as it did not affect food production—funding biofuels would be better than subsidizing commodities or paying farmers not to produce. Another respondent stated that biofuel production should be subsidized the same way sugar production was subsidized, through a compliance payment structure, to help biofuel production be profitable.

8. What is the best end use of Hāmākua-produced biofuels: electricity or transportation?

Three of the twelve respondents felt that transportation would be the best end-use for Hāmākua-produced biofuels. Of those that chose transportation, many felt that other resources, like wind, solar, nuclear, or geothermal, are better for electricity. Transportation biofuels should be comparatively more cost-effective.

Two respondents felt that electricity would be the best end-use, and one felt that both are important. Those who felt that electricity would be the best use said that electricity generation is more straightforward and that technology to make transportation fuels has not yet been proven to be economical.

Four of the respondents were less direct when responding. Three were unsure, but mainly concerned that the existing eucalyptus trees would be put to the best economical and environmental use. The lack of commercially available technology was also a concern. Finally, another respondent felt that biofuel production would lock up the land for too long.

9. Do you, or are you planning to, integrate renewable energy technology into your operation? Would you consider biofuels? Do you see any benefits in subleasing part of you property of co-production with a bioenergy company?

Ten of the twelve respondents are using or considering renewable energy technology on their operations—four are using or considering solar; two have hydropower and wind; and two have wind and solar. Two are considering biofuel production. Most would consider using biofuel in farm equipment if it was cost-competitive with gasoline or diesel. The operation that is currently utilizing the most renewable energy started projects in the late 1970s and has 4 MW of wind power and 7 MW of hydropower, with an additional 23 MW planned. One of the smaller diversified operations is planning to utilize wood combustion for heat.

Most respondents did not see an advantage in subleasing part of their property for co-production with a bioenergy company—either their property is too small, they felt that it would negatively impact their yield, or they felt that tenants would not be good stewards of the land. One of the respondents that is seriously considering biofuel production is currently leasing a parcel of land to a forest consultant company, but has not made an agreement with any bioenergy companies. That respondent is considering co-production with cattle grazing, if it will be economical for both them and the bioenergy company. The other operation with potential biomass production is planning to produce diesel, jet fuel, and gasoline in a co-production system with cattle grazing. That operation is also interested in a research institute to look into several projects, including 1) co-production with nut trees, cattle and timber, 2) thermo-chemical processing and 3) gasification.

10. How organized is the agricultural community in Hāmākua? Are there active co-ops in the area? Do you participate in a co-op? Please describe your participation in the agricultural community.

Though all respondents are involved in at least one agricultural organization, only two of the twelve respondents feel that the agricultural community in Hāmākua is organized. However, most feel that the cattle ranchers are organized. Ranches are very conscious of their industry and spend a lot of time on industry issues—lifestyle choices, new products like wagyu beef, and grass finishing.

There are several groups active in the area in which the respondents participate, including Hakada Live, TropAg, the Hawai‘i Farm Bureau Federation, and the Hawai‘i Cattlemen’s Association. There is also the farmer’s market, livestock associations, and rancher’s associations. In addition to the organizations, there are several co-ops, including Hāmākua-North Hilo, Waimea farmers, and Hāmākua cattlemen. One respondent said that attempts to provide farmer education and entrepreneurial classes has been unsuccessful, outside of the UH

Extension Service.

Two respondents have had negative experiences with co-ops in the area. One noted that the failure of distribution co-ops in Hāmākua is the fault of corrupt participants—leaders that steal from the co-op have cost other members much of their profits. He noted that co-ops could use assistance from outside agencies to develop overarching strategies. Another respondent recalled an experience with a county-initiated co-op in 1993—1,000 acres in three locations along the coast, but farmers were not allowed to live onsite. Now that co-op is almost entirely dysfunctional. He also mentioned that the farmers' market in town does not generate enough revenue for most small farmers to make farming economical.

11. Do you think there will be community benefits from the biofuel companies? What kind of benefits would you like?

Six of the twelve respondents felt that the community should see a decrease in energy costs, and that Hāmākua needs local economic stimulation, though most are not expecting a large number of jobs to be created from any bioenergy company. Other desired benefits include energy self-sufficiency; sustainable land stewardship; fire and disaster management plans for the community; and provision of services like affordable housing, schools, and hospitals.

Five of the respondents are not actually expecting any direct community benefits at all from new biofuel companies. They felt that private businesses should make the land productive, provide good jobs, and supply a tax base that could support the needed infrastructure, and should not end up draining the tax base established by residents. The latter was mentioned specifically because it would be disappointing for the community to receive direct benefits from a company that has a negative influence on the tax base.

12. How do you see Hawai‘i Island in relationship to the other islands, economically and/or socially?

Many of the respondents felt that Hawai‘i Island has the potential to be self-sustaining in food and/or fuel production. One interviewee specifically stated that the Hāmākua coast has enough land and was historically an economic engine of the State. However, there is a general sentiment that lawmakers in Honolulu and Hawai‘i County have not consulted the community when land use policies are made and lease changes occur. Politicians need to fully consider all consequences and hold public dialogue before future changes are made. One respondent felt like that is changing since government agencies are reaching out to community organizations. Most respondents agreed that Hawai‘i Island has vast land resources, but as one pointed out, the limiting factor is labor.

In regard to policies, county regulations were not designed for farmers. A farmer that wants to build a greenhouse is held to the same building code as someone who wants to build a house. Some regulations need to be relaxed, otherwise farming cannot be profitable or farmers will conduct activities, like grubbing or building, without a permit.

Socially, the respondents perceived Hawai‘i Island as more rural, steeped in the traditions of sugar plantations. As a result, there is a polarization between new transplant residents and long-time blue-collar residents over the type of industries that should develop in the area. Also, ethnicities are less socially integrated.

13. How do you envision the future of agriculture in Hawaiʻi? How does your operation fit into that vision of the future?

Ten of the twelve respondents have a generally optimistic view of the future of agriculture in Hawaiʻi and envision their operation as a part of future successes. Many feel that Hawaiʻi can be self-sustaining in terms of food production, but there is a major need for transportation infrastructure in order to get products to market. Infrastructure would allow the supply of products from Hawaiʻi Island to get to other islands, thus making agriculture more economically feasible by widening the market. One respondent voiced a desire to see value-added products from a diversified forest industry being produced in Hāmākua.

One interviewee felt that a successful future with biofuels would mean that energy costs would decrease. If that happens, food production costs would also decrease because of the use of energy as an input in production. Ideally, biofuel production will take up the areas unfit for food production. However, more lands could possibly be deemed Important Agricultural Lands (IAL) if the designation is made with both food and biofuel production in mind, which could possibly protect more land from other uses. Either way, Hāmākua needs agriculture if its people want to maintain their rural lifestyle. History shows that rural communities that lose agriculture collapse.

Two of the respondents made specific reference to agro-tourism activities as a part of their operations and a large part of the future of local agriculture. There is a growing interest in the branding of Hawaiʻi produce in local gourmet cuisine, so the niche markets are expanding as restaurants and grocery stores continually seek unique products, and farmers are marketing their products as a tourism opportunity. One respondent described the decline of food imports as linked to rising oil prices, but still sees a future for the export of high-end products. In the meantime, individuals will need to either grow their own food or buy more locally produced products.

Sustainability, both economical and environmental, was mentioned as a part of the vision of the future. One participant felt that people should utilize their environment so that land is enhanced and improved to carry on for future generations. This can also be economically feasible, and allows ranchers to be competitive because keeping plants healthy drives down unit cost of production, so ranchers can have twice as many cattle in the same area. Another respondent fest that perception, or seeing the bigger picture, is important. With such a viewpoint, preserving environment is not infeasible.

Respondents that expressed a less than optimistic view of Hawaiʻi's agriculture future pointed to poor leadership on the state level and a lack of political will within the agricultural community. With the proper incentives, Hāmākua could be an example of how agricultural communities can be viable. One respondent stated that the local cattle industry could grow if slaughterhouses were more available—mobile slaughterhouses and onsite refrigeration works on the mainland on a limited basis, but is not allowed here for food security regulations.

In the current political climate, some see Hāmākua developing into a retirement community with only the largest land holdings by Kamehameha Schools, the State, and the County available to farmers—the rest will be developed into housing. A few respondents noted that there have been very few new farmers in the area over the last 20 years and very few young people want to go into farming. At the same time, there is a growing Southeast Asian farming community along the coast.

14. On a scale of 1-10, 10 being the highest, how would you rate your sense of urgency needed in using bioenergy in addressing current energy situation?

Responses range from 1-10, with an average of 6.33. When ranked, the middle number is 7.75, and the most frequent response is 10.

Those at the lower end of the scale felt that there are more efficient alternatives, like solar, wind, or geothermal. Others who ranked urgency at around 7 would like to see biofuels become a reality because the eucalyptus trees in Hāmākua are an unused resource. They also felt that renewable energy is something that should have happened a long time ago. Those that answered an 8 or below feel that there are too many unanswered questions. The interviewees who answered between an eight and a ten felt that Hawaiʻi can utilize all forms of alternative energy and it is needed now. All of the respondents feel that Hawaiʻi, should be moving toward lessening our reliance on fossil fuels.

III. *Business Leaders: Forestry and Energy*

1. What is the best end use of Hāmākua-produced biofuels: electricity or transportation?

There is consensus among the respondents that biofuels are a feasible energy solution for Hawai‘i for electricity and/or transportation; however, there are varying opinions regarding which types of feedstock are most feasible and some concerns regarding processing, technology, and market. There is also a split between those who felt that biofuels are more promising for electricity and those who felt it is better to use them for transportation. Some respondents noted that the choice for end use is entirely market driven. Most respondents felt that the transportation fuel concept has promise, as even if there are electric cars, tractors and big trucks still need diesel; some showed concern regarding the technology needed to process biomass into fuel.

2. Is there a specific biofuel crop or crops that you think would be best for Hāmākua? Why?

The participants had varying thoughts on the best inputs and species. Though not all answers were specific to Hāmākua, the following were listed as possibilities:

- Jatropha
- Kukui Nut
- Moringa
- Hemp
- Bamboo
- Oil palm
- Grasses
- Luceana
- Eucalyptus
- Sweet sorghum
- Sugarcane

Jatropha, oil palm, and sweet sorghum, were the most talked about. Most experts agreed that monocropping, though not the most sound environmentally, makes the most economic sense for large-scale harvesting. A few participants felt that several different species should be considered at once, each one growing where it was best suited. This practice is reminiscent of the traditional Native Hawaiian style of the ahupuaa land use system.

Some respondents expressed the sentiment that inputs like eucalyptus should be evaluated for their higher value-added products and not only their combustible qualities. Only a few experts addressed conversion processes—gasification was mentioned as a good process with no emissions according to today’s EPA emission standards.

3. Do you plan for mixed use on your bioenergy production land? Would you consider integrating other types of renewable energy sources into your operation?

Respondents are open to mixed uses as long as they fit into their business plans. Interviewees were reluctant to speculate about integration beyond their operation, as their primary focus is the production of their intended products. However, all of the participants surveyed were open to negotiations with others who had plans for mixed uses. One such example of this is the use of eucalyptus by Hāmākua Mushrooms to grow their product. The trees are purchased from the management company and turned in to sawdust to make a mushroom media. Respondents were hopeful that these types of relationships would be formed both to help local businesses and to make companies more sustainable and diversified.

4. How much land does your operation require? Do you own or are you interested in specific areas?

This was a complicated question for many of the businesses to answer. Because many of the companies are still in start-up and planning stages, they are not exactly sure how much land they will need or be able to obtain. This is especially true in regards to the eucalyptus trees. The stands are often owned by the landowner who leases just the trees to various companies. These companies then hire a management company to take care of the stands until they find a use for them. Also, depending on the crop and the anticipated yields, the necessary acreage is difficult to determine. For this reason and others, the estimates of land needed ranged from 9,000 to upwards of 50,000 acres. The acreage which the respondents said they need reflects the amount of land which the companies would like to secure prior to investing the capitol in processing plants. Discussed on a yearly basis, one business gave the estimate of 2,000 acres of biomass processed a year (around 150 acres of biomass processed each month).

5. What conversion process(es) do you plan to use? What are your expected outputs? How much energy will your operation produce in relation to local demand?

Some of the respondents said that their companies would be using boilers. In this process, the biomass is chipped up and then burned to create electricity. One of the companies who is using this process projects their operation to supply 22 MW of firm power. This company noted the resistance from the public at the idea of burning wood, though stating that the burning of oil or coal is worse. Another process which was discussed by respondents was Biomass to Liquid. This is a CarboV gasification & Fischer-Tropsch synthesis which creates synthetic diesel. Though there are different processing techniques, ultimately, the crop choice will determine the type of processing plant.

6. What other inputs does your operation require? What type of infrastructure? Who will provide the infrastructure?

All of the responded noted they would need some sort of processing plant. Some of the participants described how their operations would be located in or on old sugar processing plant locations. One of the companies is retrofitting the old bagasse broiler in a sugar mill; others will need different technology and machinery. One of the businesses stated that the lathe will be the heart of the mill; another business will need a boiler turbine.

None of the participants mentioned the need for outside inputs during the processing. One respondent said that rather than ship to the island what is needed to make power, their business will recycle what is already there.

Most of the respondents recognized the need for good roads as transporting the biomass from field to factory is a major part of their operations. It was stated that the necessary roads are already in existence from the sugar operations and just need to be repaired.

7. What will be the byproducts of your operation? Do you have a plan to use any byproducts?

One of the businesses will have fenceposts as a byproduct. Another respondent speculated that with the right crop, they would be able to produce island grown cow food, which they postulated would help local ranchers. Sawdust was also a byproduct mentioned that could be sold to local mushroom growers.

Another respondent said that there is no waste and that absolutely everything has a use. An example given is the ash that comes out of the broiler. This is said to be a very good fertilizer that could be distributed over the harvested fields to replenish the land.

8. When is your product expected to be market ready? Will your biofuel be used locally? Who will your buyers or potential buyers be?

This was another difficult question for the businesses to answer. Their timelines seemed to depend on permitting among other things, all of which are unsure at best. The earliest start date given was 2011 and the latest was 10-12 years out.

9. How do you see Hawai‘i Island in relationship to the other islands, economically and/or socially?

Some respondents discussed the importance of agriculture. They noted that many of the residents of Hawai‘i Island were tied to sugar in some way and that even though the mills are gone, large-scale agriculture is needed to occupy the lands so they do not slip into gentleman farm developments. Because this has happened on other islands, keeping agricultural land in production is even more important for Hawai‘i Island. Another participant called Hawai‘i Island the bread basket of the state, recognizing the need for food production on agricultural lands.

10. What are your top three concerns about biofuel production in Hāmākua? What do you think are the community’s top concerns?

Several participants responded that negative environmental impacts include: erosion, water use, diversion of water, invasive species, and chemical fertilizers (noting past use of heptachlor). One participant noted that GMO agriculture would not be welcomed if a modified crop was chosen; however, another respondent was undecided about the use of GMO crops in their production.

In terms of community impacts, some participants mentioned that biofuel production and/or agriculture should be in harmony with the community and consistent with the surrounding uses. Some of the participants felt that energy producers would provide benefits to the community through public-private partnerships with county and local government to help with local issues. Others thought that the benefits would be reducing the fire hazards (regarding eucalyptus in Hāmākua), increasing jobs, and creating an industry that would be able to allow residents to work where they live and earn wages that were sufficient to sustain them and their families.

One major concern for businesses is the process of permitting and obtaining all of the necessary documents to open for business. As one participant said, “time is money”, and they noted that permitting takes a really long time. Though the respondents wished the government would act more quickly upon their requests, they did not want to bypass the concerns of the public. The consensus among participants was that the government should be more proactive in addressing the concerns of the community and the process of permitting business projects.

11. How will your operation benefit the Hāmākua community? (Or, phrased as: What types of benefits will you provide to the Hāmākua community? For example, how many jobs will be created?)

All respondents thought that the biggest benefit to the community would be jobs. The estimates of the jobs created ranged from 25 direct employees to 140 employees including secondary industries. All of the respondents said their facilities would have no minimum wage jobs. They said that the wages would be living salaries and that they would like to hire locally so that individuals feel invested in the company they work for.

One respondent noted that even the agricultural jobs would pay a competitive wage. They said that it is not going to be like the old plantations, now it is mechanized harvest with skilled workers, not laborers.

12. On a scale of 1-10, 10 being the highest, how would you rate your sense of urgency in using biofuels to address Hawai‘i’s current energy situation?

Responses range from 3-10, with an average of 8.6. When ranked, the middle number is 9.75, and the most frequent response is 10.

The majority of the participants’ sense of urgency fell between 8 and 10, overall they perception was very urgent. One participant felt that though energy issues were important, projects take time, thus the urgency of the matter to is a bit unrealistic. Those participants who rated their sense of urgency close to 10 felt that biofuel use need to start happening right now.

The one participant whose sense of urgency was on the lower end stated that Hawai‘i would realistically be dependent on oil for awhile and that the necessary technologies to affect our dependence on oil were not obtainable now but might be in the future.

IV. *Public Representatives: Energy, Water, and Community Planning*

1. Do you think biofuels are a feasible energy solution for Hawai‘i in the areas of electricity and transportation? What are the best alternatives to biofuels?

Some respondents thought we should definitely be using biofuels and that it is commercially viable, but there are others that thought the technology is not quite ready and a decision about biofuels would be premature. However, respondents generally agreed that biofuels can definitely be part of the energy solution. Most respondents agreed that existing electrical infrastructure might be quite easily converted to be compatible with biofuels, which would make biofuels an attractive interim solution.

Most of those in favor of biofuels thought that it can best be used for transportation, mostly because there are other alternatives for electricity production, such as solar, wind, geothermal, natural gas, hydroelectric power, or wave technology. Alternatives for transportation energy include electric vehicles and hydrogen. Other concerns include: figuring out the most efficient conversion process, sustainability (economic, and environmental), maintaining a community’s sense of place, economies of scale, and affordability.

2. Are there tradeoffs, opportunity costs, and/or barriers associated with biofuels? If so, what are they?

Respondents often noted that there is a chicken or the egg debate around local biofuel production – there is no processing plant because there are no crops and there are no crops because there is no processing plant. The industry is also so new that there are limited examples to research and replicate. Other barriers include:

- a high degree of community suspicion and resistance
- politics
- coping with energy intensity and fluctuations on the grid
- questions around producer profitability, particularly for farmers
- lack of infrastructure, including roads, water, and processing plants
- increased traffic and congestion
- need for education on environmental issues
- reality of lifecycle costs and carbon footprints

Responses for opportunity costs or tradeoffs included competing land use (food vs. fuel and the need to diversify agriculture), owners’ preferences, and the dangers of monocroping. Some recognize that tree crops have a larger opportunity cost because there is a long term commitment. The production of biofuels is also in lieu of developing a value added product.

3. Is there a market for biofuels in Hawai‘i? If so, what is the market?

Some respondents think there is a market for biofuels, while others think there is not. Those who believe there is a market agree that it should be local (Hawai‘i Island and the rest of the state), and that there is a continuing need for liquid fuels, especially biodiesel in the transportation sector. Challenges cited include: the lack of infrastructure and processing plants; the potential cost to the consumer; convincing the utilities to participate; community opposition; and economies of scale. Hāmākua is a sugar area and people who lived with this probably would not mind production. In contrast, newcomers appreciate their serenity.

4. Biofuels can be produced from a wide variety of inputs and species and require conversion processes. Please list, to the best of your knowledge, what you feel are the ideal species and conversion processes. Are there "best practices" regarding these species and processing?

As far as species are concerned, most responses were anecdotal. Most acknowledge that Hawai‘i is going through rigorous evaluations in academics, business, policy and the community. Consistently, respondents and administrators note that more research on yields, economics and environmental impacts need to be conducted so that investors can get a broader understanding of the industry. All species and processes have their tradeoffs, whether it is increased inputs or excessive environmental impacts. Species most commonly mentioned include oil palm, jatropha, sugarcane, and banagrass. Some people believe biofuels should be approached by economics per acre. Currently, scale cannot be determined without extensive energy audits and research on economics of production and a clearer picture of environmental impacts. Overall, respondents agree that best practices should reinforce stewardship and conservation.

5. There are several potential sites for biofuel production in Hawai‘i. Do you think Hāmākua is a good site for biofuel production? What are the best types of land for biofuel production?

Most respondents agree that in terms of agriculture, Hāmākua is a great place to grow crops because there is a lot of land, rain, water, sunlight, and deep soil. Additionally, biomass production there could be minimally intrusive on the community because there are lots of land locations there that are removed from the immediate vicinity of the community. Also, the eucalyptus is already there. Some are concerned about the soil health due to the sugarcane era and some question the availability of water in Hāmākua, especially for biofuels since it will require a fairly large footprint. Others doubt that fallow land will be used for any type of agriculture, because landowners might be waiting to sell it for development.

Concerns about Hāmākua specifically include soil erosion, community opposition to projects and proximity to plants, available infrastructure, and matching climate to species (and changing climate projections). Other potential areas for biofuel production are marginal lands, lands mauka of the highway, and lands on other islands.

6. What is the best use for currently fallow agricultural lands?

Food, fuel, and fiber were listed as the best use for currently fallow lands. However, interviewees were hesitant to accept "fallow" land as land that is not being used, since ranching is a use. Most agreed that the best use for the land will depend on factors such as what can grow there, what is economically and socially feasible, and zoning regulations. If the farmers can find a profitable crop, they will grow it. Those in favor of using land for food production are in favor of small-scale, sustainable production and potential co-production. Those against biofuels being produced on fallow agricultural lands specifically stated that biofuels should not be produced on state or public land.

7. What could the potential consequences and impacts of biofuel production be on (1) environmental health and (2) the local community?

Creation of sustainable, local, skilled, and well-paying jobs is one of the first things respondents cited, particularly jobs that allow workers to stay within the region. Another beneficial consequence they saw is the creation and use of locally produced electricity that is reflected in a decreased cost for the end user. One example of a positive program is related to Puna's geothermal plant, which maintains a community trust fund to help residents relocate away from the plant.

Another theme mentioned is the effect biofuels would have on agriculture in the communities. The concerns range from encouraging a healthy agricultural sector to wariness over global competition in a commodities market. Some are concerned with the dangers of monocropping and discouraging entrepreneurial innovation in favor of large-scale farming. Everyone recognizes that food production is an important aspect of the picture, with some people advocating food self-sufficiency over fuel. Many admited that the island's ability to produce more food locally is desirable but uncertain, acknowledging that there are very few people going into agricultural food production because land is too expensive, it is not often profitable, and the infrastructure is either non-existent or needs maintenance. Existing niche markets are more profitable, producing a high value per acre. One respondent suggests that the food issue is a much larger question than its relationship to biofuels. Responses reveal some concern around clear cutting versus incremental harvesting.

Related to agriculture, many recognized that Hawaiʻi Island has a rural lifestyle, and there is a desire to maintain community identity. Another common concern centers on infrastructure, particularly in relationship to the roads, trucking, and traffic congestion. The range of responses raised general concerns about the impacts of biofuels on the tourism industry, the increase in gentlemen farms, and encouraging compact villages. Some government administrators and officials recognize a vocal majority steers much of the community input so the opinions of a significant segment of the population may not be reflected. Much of the community is suspicious of new industries. It is suggested that businesses interested in moving in should be open and honest about their intentions and have a long term plan that includes an exit strategy. Other environmental impacts include effects on the observatories and increased noise.

Erosion, byproducts, contamination, toxicity, emissions, watershed restoration, and depletion of soils are some of the major environmental impacts noted by the interviewees. Many of the questions surrounding the production of biofuels cannot be determined until production begins. There is a fear of returning to the plantation days, particularly to the collapse of the plantation, when the community was left in turmoil. Other environmental concerns include management of invasive and endangered species.

8. Assuming we are on the path for widespread biofuel use, what is your idea of the end-vision and how would you measure future successes?

One government official stated that liquid fuels are essential for jet and cargo transportation. Liquid fuels provide efficient and portable energy storage comparable to liquid fossil fuels. Most agree that it is important to be diversified. Answers for measuring success include biofuels viability as a business, integration into the overall energy picture, improvement of community life both economically and socially, creation of long term jobs, and a decrease in energy costs. Other responses described the ways communities would function as regional and self-sufficient with farm and energy cooperatives. Some also mentioned having both locally grown bioenergy and food as an end vision.

Environmentally, respondents saw success in biofuels as supporting a thriving ecosystem (or at least not competing with one), clean coastal waters, and restored forests. They want to see communities giving back more than they take, systematically reducing dependence on fossil fuels and reaching some level of self sufficiency as a state. They mentioned wanting the people to have a conscientious effort to reduce pollution and encroachment while encouraging biodiversity.

9. How do you feel about using government funding or resources for biofuels production? Do current policies allow for the streamlining of processes to start a biofuel production operation? Do they adequately address concerns about negative potential outcomes?

Most respondents do not see any negative consequences with streamlining; and they seem to be in agreement that there is too much bureaucracy. They also are mostly in favor of government money being used for research and development. Government can also help because they have zoning authority, support innovative polices, and can help to ensure private companies meet requirements. Government-private partnerships may be the best way to provide both oversight and transparency for biofuel projects. The government can ensure that requirements are being met and benefits are shared. Additionally, the use of government funds can, with the proper policy, require accountability,

Potential consequences of streamlining can be impacts on environmental health, thus studies should be done on potential externalities. Most also agree that subsidies are inappropriate once a technology becomes commercial; long-term and significant subsidies are not sustainable.

10. How do biofuel plans relate to local, county, and state development plans? Where are the decision points for public interaction in current plans and planning processes relating to bioenergy production?

Some of the responses note that there is community development plan (CDP) moving forward. They believe the CDP process is an ideal time to establish a new relationship between government and community that is collaborative and transparent. leaders are stepping up to take the lead, making sure there is quality public input, but they also see streamlining from the PUC as curbing participation. They see renewable energy tax incentives and tax breaks from all levels via the federal stimulus package through the state and to the county level.

11. How do you see Hawai‘i Island in relationship to the other islands, economically or socially?

Hawai‘i Island struggles more than other islands both economically and socially, but has the most potential for technological development and production with relatively inexpensive land. Some believe that Hawai‘i Island is well suited to be an asset for food and energy production for the state. One respondent felt that Hawai‘i Island is known for its diversity in people, economic engines, lands, and environments. The people of Hawai‘i Island are independent, entrepreneurial, and have potential to be self sufficient while maintaining a good quality of life.

12. Do you think there will be community benefits from biofuel companies? What kind of benefits would you like?

Some note that they have not gotten to that point in the discussion but that the companies should strive to become part of the community. The real benefit should be long term, sustainable jobs. While some respondents and administrators state that they see some pressing community needs, others warn that companies should first prove its worth as a business, through a business model that supports its industry. They follow up by saying undoubtedly there will be tangible community benefits (that should come from the heart), but upfront offers could be considered bribes.

13. How in the past have industries or attempted projects affected the community?

In the past, a lot of problems came down to not engaging the community. Examples are: the paper mill, which is outdated since they don’t have industrial zoning in the middle of towns anymore; sugarcane, which left a plantation mentality with the sense that everything will be provided; controversial eradication plans for papaya crops; and the establishment of the Natural Energy Laboratory of Hawai‘i Authority. Some suggest that there is a fear and distrust in change and government, therefore projects should start at the community level, building relationships and speaking to people.

14. What are your top three (3) concerns about biofuel production in Hāmākua? What do you think are the various stakeholders’ (community, ag, biofuel, etc) top concerns?

Respondents seem to agree that including the community in the process is a top concern. The themes range from paying living wages, transparency, location of plants, ensuring public health, and the ability to make informed decisions. Another common theme is land availability for other uses and taking care of the environment. Many feel the industry should not be delayed and needs to move forward within a year. Other responses include more being more localized and cost savings passed on to consumers.

15. On a scale of 1-10, 10 being the highest, how would you rate your sense of urgency in using biofuels to addressing Hawai‘i’s current energy situation?

Ratings range from 1-10, with an average of 7.1. When ranked, the middle number is 7, and the most frequent response is 10.

Generally, respondents thought that the people of Hawai‘i are using too much fuel in general, and should use biofuels as part of a larger solution to help transition to a new diversified energy portfolio. However, the details and economics need to be worked out. Since Hawai‘i cannot do biofuels on a large scale (due to lack of availability land, especially contiguous land), small-scale operation trials should be done to evaluate if they will work.

Appendix IV. Interview Participants

We would like to thank and acknowledge people who participated in our study by contributing their thoughts and expertise.

Stephen Bowles, *Hydrologist and Kohala Ditch Advocate*

Donald Bryan, *President and CEO, Tradewinds Forest Products*

Michael "Corky" Bryan, *Vice President of Livestock Operations, Parker Ranch*

Kyle Christensen, *Island Dairy*

Ben Discoe, *Āhualoa Egg Farm*

Jose Dizon, *General Manager of Operations, Hawaiʻi Electric Light Company*

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Julie Myhre, *Energy Management Analyst, Department of Water Supply*

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William Sam Pintz, *Senior Resource Planning Analyst, Hawaiian Electric Company Inc.*

Michael D. Poteet, *Assistant Agronomist, Hawai‘i Agriculture Research Center*

Ada Pulin-Lamme, *Friends of Hāmākua*

John B. Ray, *General Manager, SunFuels Hawai‘i LLC*

Jim Reddekopp, *Hawaiian Vanilla Company*

Dr. Herbert M. "Tim" Richards III, *President and General Manager, Kahuā Ranch*

Dr. Michael Robotham, *Assistant Director for Soils Science and Natural Resource Assessments, USDA-Natural Resource Conservation Service – Pacific Islands Area*

Peter Rosegg, *Corporate Communications, Hawaiian Electric Company*

Walker Sanders, *President, Hilo-Hāmākua Community Development Corp.*

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Steve Shropshire, *Aloha Green*

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Steve Skipper, *Big Island Resource Conservation and Development Program Coordinator, USDA Natural Resource Conservation Service*

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