Hawaii Bioenergy Master Plan

Potential Environmental Impacts of Bioenergy Development in Hawaii

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Executive Summary

An evaluation of the potential environmental impacts associated with bioenergy development in Hawaii was conducted as part of the Hawaii Bioenergy Master Plan mandated by Act 253 of the Hawaii State Legislature in 2007. This effort included the characterization of the general environmental impacts and issues associated with bioenergy development, the identification of potential environmental impacts in Hawaii for each portion of the biofuels value chain, and recommendations for State action.

Despite the obvious potential benefits of reduced greenhouse gas (GHG) emissions and energy self-sufficiency offered to Hawaii by bioenergy development, there are many potential environmental impacts that need to be considered when developing bioenergy policy and projects in Hawaii. The following is a summary list of the potential environmental impacts and issues associated with bioenergy development in Hawaii.

- Reduction in greenhouse gas emissions and use of fossil fuels
- Invasive species management
- Agricultural land use conflicts
- Water use and water rights
- Water pollution/quality
- Soil quality
- Air quality
- Residue management
- Socio-economic community impacts
- Cultural impacts
- Transnational environmental issues

The following list of recommendations has been developed based on stakeholder input and information collected in the preparation of this study.

1. Environmental Impact Assessment – As specific proposals are put forward for development of aspects of the bioenergy value chain, environmental assessments or environmental impact statements should be completed pursuant to the State of Hawaii environmental review law (Chapter 343, HRS) and the Department of Health Title 11-200 administrative rules governing the review process. It should be noted that not all bioenergy projects may trigger Chapter 343, HRS due to their proposed locations, land ownership, and/or funding.

   Environmental assessments and impact statements should include evaluations of the potential social, economic, and cultural impacts associated with the proposed projects, as required in the Title 11-200 administrative rules for the environmental review process. Assessments should strive to include analysis of how specific proposed projects for bioenergy development in Hawaii will effect and be affected by international market conditions. This analysis will give transparency to the potential indirect and direct environmental impacts of biofuels development in Hawaii.
2. **Life-Cycle Analysis (LCA)** – Life-Cycle Analysis (LCA) is the cradle to grave systems approach for examining technology and systems. LCA should be used to examine the specific technical aspects of any proposed biofuels value chain, the crops, energy requirements, emissions, land use changes, water use requirements, wastes, logistics, conversion technology, distribution, and end use to determine the net energy and greenhouse gas balances of the biofuel. This process is being used nationally and internationally to evaluate bioenergy development and could be employed for analysis of local conditions and permitting.

The State should establish requirements for LCA based on Hawaii’s specific environmental conditions, goals and needs. The State should establish guidelines for LCA, including certification of LCA methodologies, and the minimum attainment of positive net energy and greenhouse gas balances. LCA should be used as an integral component in a biofuels certification process.

3. **Conservation Agriculture** – Since most environmental impacts from bioenergy development are found in the feedstock production phase, the State should require appropriate conservation agriculture practices for biofuels feedstock production. This would help reduce water consumption, use of pesticides and fertilizers, and pollution.

4. **Weed Risk Assessment (WRA)** – Weed Risk Assessment (WRA) should be required for all candidate crops for biofuel production. Since Hawaii has sensitive natural resources that are susceptible to invasive species, the State should establish criteria for restricting certain candidate crops that may have the greatest potential for harm. It may also want to limit introduction of certain crops from areas near sensitive habitats depending on the individual characteristics of the candidate crop.

5. **Examine the Issue of Agricultural Land Use and Biofuels** – The State should commission a study to examine the potential issues related to agricultural land use and biofuels. The potential impacts to local agriculture from an introduction of large-scale biofuel development may be significant. Of particular importance is the potential loss of local food-crop production as prime agricultural lands are shifted to biofuels and other non-agricultural uses.

The study should examine how existing agricultural practices and uses of land, including small farming and ranching, may be impacted by the introduction of incentives and subsidies for biofuels. This should include an analysis of food security and fuel security issues in Hawaii. The study should also examine how the conversion of prime agricultural lands to non-agricultural uses may affect biofuels development and long-term viability.

6. **Encourage Use of Existing Infrastructure** – To minimize the potential environmental impacts from the development of new infrastructure needed to support bioenergy, the State should encourage the use of existing conversion facilities, pipelines, and other infrastructure where applicable.
7. **Community-Based Bioenergy Working Group** – Many stakeholders expressed concern about the lack of information regarding environmental issues and the State’s plan for bioenergy development. Many requested a forum to exchange information. The State should establish a community-based working group with representatives from various stakeholders including, but not limited to, representatives from State of Hawaii Departments of Agriculture; Business, Economic Development and Tourism; Land and Natural Resources; Attorney General; bioenergy entrepreneurs; large landowners; small farmers; environmentalists; Native Hawaiian groups; the power industry; etc.

This forum would be useful for creating community dialogue and understanding about bioenergy development and environmental issues in Hawaii. It could also be used as a tool for gathering information for social and cultural impact assessment.

8. **Biofuel Certification Program** – To safeguard Hawaii’s unique native eco-systems and culture, and support sustainable biofuels development, the State should explore the possible development of a certification program for biofuels. Many countries are proposing that biofuels meet certain mandated targets or minimum goals to receive subsidies and government recognition. A certification program in Hawaii could include various sustainability requirements related to net energy and greenhouse gas balances, invasive species protection, water and land conservation, protection of local food supplies and farming, and other social and cultural issues.

It should be noted that certification programs are difficult to employ and may, if too unwieldy or burdensome, constrain the development of the local biofuel industry in Hawaii. If employed, certification should be targeted at specific local problems and tailored to meet specific sustainability goals established by the Legislature.

Due to the complexity of the issues, the State should commission a separate study to examine biofuels certification for Hawaii. The study should include analysis and recommendations for sustainability requirements, implementation and timing guidelines, and the specification of departmental permitting responsibilities. A central component of the study also should be the analysis of the various certifying methods including government run certification programs, preliminary certification for “First-Movers”, voluntary certification, and third-party certification. Optimally, certification of any sort should not add to the duration of the overall permitting process. Efforts should be made to coordinate existing permitting and disclosure processes and reduce or eliminate redundancies.

Optimally, a certification program should be established prior to the development of new subsidies for biofuels in Hawaii. However, due to the State’s desire to encourage rapid development of bioenergy there may need to be some discussion about creating initial screening processes and preliminary certification to help first movers with “shovel-ready” projects or demonstration projects. If a “First-Movers Program” for preliminary certification was established, any participating programs should be required to complete a full and timely certification and LCA as part of their final
permitting/compliance. Strict precautions would need to be taken in a preliminary certification process to safe-guard against invasive species and any other irreversible commitment of resources that may be proposed by a project under a “First-Movers Program”.
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  Summary Notes from Environmental Impacts Session at April 2, 2009
  Stakeholder Meeting
1. Introduction

Increased petroleum costs and the threat of global warming and climate change are pushing governments and industry to explore the transition to renewable and more ecologically friendly energy sources. Bioenergy\(^1\) is identified as one of the potentially viable sources of renewable and environmentally friendly energy for Hawaii. Bioenergy crops can reduce or offset greenhouse gas emissions by directly removing carbon dioxide from the air as they grow and may increase stores of soil organic carbon over time. Resources can also be grown or produced domestically from a wide array of plants or wastes including corn, sugar cane, oil palm, waste cooking oil, switchgrass, and eucalyptus to name few. Biomass resources can be used for both liquid or solid biofuels for transportation and electrical power generation.

In recognition of the potential for bioenergy to help meet the need for renewable and environmentally friendly energy in Hawaii, the 2007 Hawaii State Legislature passed legislation mandating the development of a Bioenergy Master Plan, subsequently enacted as Act 253, Part III. The primary objective of the Master Plan is to develop a Hawaii renewable biofuels program to manage the State’s transition to energy self-sufficiency. For this study, the presumed goal is displacement of 20% of 2007 transportation (gasoline and diesel) and power generation (diesel and fuel oil) fuel use with bioenergy resources by 2020. The Master Plan is intended to address 1) Strategic partnerships for the research, development, testing, and deployment of renewable biofuels technologies and production of biomass crops; 2) Evaluation of Hawaii's potential to rely on biofuels as a significant renewable energy resource; 3) Biofuels demonstration projects, including infrastructure for production, storage, and transportation of biofuels; 4) Promotion of Hawaii's renewable biofuels resources to potential partners and investors for development in Hawaii as well as for export purposes; and 5) A plan or roadmap to implement commercially viable biofuels development.

The Bioenergy Master Plan is constructed around implementation of the biofuel value chain including feedstock production, feedstock logistics, conversion, distribution, and end use of biofuels. The plan addresses various issues for implementing the value chain including water and land resources, distribution infrastructure for both marine and land, labor resources, technological production of feedstocks, permitting, financial incentives and barriers, business partnering, and policy requirements. Act 253 also directs that the Bioenergy Master Plan identify and analyze the environmental impacts of transitioning to a bioenergy economy.

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\(^1\) Bioenergy technologies use renewable biomass resources to produce an array of energy-related products, including electricity, liquid (biodiesel and ethanol), solid, and gaseous fuels, heat, chemicals, and other materials. Biomass is any organic matter that can be used for energy production, including trees, agricultural food and feed crops, crop and wood wastes, aquatic plants (algae), animal and municipal wastes, and dedicated energy crops.
2. Consideration for Bioenergy Development in Hawaii

Passage of Act 253 and development of this Master Plan followed the preparation of various studies in support of bioenergy development and the convening of the Governor’s Biofuels Summit and the Ag Bioenergy Workshop in 2006. These initiatives indicate that the focus of bioenergy development efforts in Hawaii has been on biodiesel and ethanol-based biofuel to reduce Hawaii dependence on imported petroleum for both transportation and electrical energy generation.

Poteet (2006) evaluated the potential for biodiesel development in Hawaii based on the development of a wide-range of biodiesel crops including soybean, flax, rapeseed, sunflower, peanut, African oil palm, kukui nut, avocado, coconut, Jatropha curass, Neem tree, and algae. Poteet found that, over time and under specified conditions, Hawaii has the potential to produce 150 million gallons of biodiesel per year or more than 55% of the total diesel usage of roughly 263 million gallons for the State of Hawaii in 2004. Poteet also highlights the co-products that would be available for use in Hawaii as part of biodiesel development - glycerin, seedcake, residual biomass, food products, and other chemical compounds. Poteet noted, however, there is a general lack of knowledge about co-products in Hawaii and that the markets for their use will need to be developed as biodiesel production is expanded.

Keffer et al.(2006) analyzed the ethanol production potential for the State of Hawaii based on four crop scenarios; 1) sugar cane grown on all soils suitable for sugar, 2) Leucaena and Eucalyptus grown on all soils suitable for trees, 3) sugar cane given first priority, grown on all soils suitable for sugar, and Leucaena and Eucalyptus given second priority, grown on remaining soils suitable for wood, and 4) banagrass grown on all soils suitable for sugar. The authors concluded that a renewable fuels goal of 20% of motor gasoline, 134 million gallons of ethanol equivalent, could be achieved under all these crop scenarios. The limiting factor for production was the amount and type of lands used in production.

In addition to identifying potential crops for production, various authors examined the land and water requirements for bioenergy development in Hawaii. The Rocky Mountain Institute’s (RMI) Hawaii Biofuels Summit Briefing Book, which outlined the State of Hawaii’s biofuels goals and issues prior to the Governor’s Biofuels Summit, highlighted the market and resource requirements needed to reach a 20% alternative fuel standard by 2020. RMI assumed that all future sugarcane production in the state, which amounts to approximately 36,700 acres on Maui and 11,000 acres on Kauai, would convert to biofuel production and that an additional 83,000 acres of prime farm land would be needed to produce enough biofuels to meet the 20% alternative fuel standard by 2020 (RMI, 2006).

Availability of water for biofuels production in Hawaii is regarded as an ill-defined variable at this point. The cultivation of irrigated crops will require substantial quantities of agricultural water and it is unclear whether there are sufficient water resources to meet the demand for the 20% alternative fuel standard (RMI, 2006). Certain technological advances including development of cellulosic ethanol and algae for biofuels do show
promise and their use may lessen land and water inputs in comparison to conventional crops and conversion technologies.

Lastly, biofuels development in Hawaii suffers in some regard from the “chicken or the egg” dilemma. Without an established end market for biofuels produced from locally grown feedstocks, there are few economic incentives to put agricultural lands into biofuel production. Conversely, potential purchasers of biofuels, like electrical generating companies, may not invest in biofuel compatible generating plants unless there is a viable and economic supply of feedstock or finished biofuels. One proposed solution is the importation of finished biofuels for use in newly developed generating plants, thus supporting creation of an end-market for local biofuels. The development of biofuels in Hawaii is ultimately based on international market forces, and locally grown biofuels will only be economically viable if they can be produced at or below import parity prices for both feedstock and finished fuel (RMI, 2006).

3. Need for Environmental Analysis of Bioenergy Development

Despite the obvious potential benefits of reduced greenhouse gas (GHG) emissions and energy self-sufficiency offered by biofuels, some studies have called into question the environmental sustainability of biofuels (Sharlemann and Laurance, 2008, Zah et al., 2007, Muller, 2008). This is mainly based on the overall environmental costs and negative greenhouse gas balances of some biofuels and their production cycles when compared to fossil fuels (Zah et al., 2007). Zah et al. (2007) (as cited in Sharlemann and Laurance, 2008) found that most first generation biofuels (21 of 26) reduce GHG emissions by more than 30% in comparison to gasoline, but that 12 of 26 have greater aggregate environmental costs than fossil fuels.

Beyond the effects on greenhouse gas emissions, the increased production of biofuels has direct and indirect environmental consequences. Water, land, and soil are all potentially affected by intensive biomass production. For example, the increased economic demand for biofuel feedstocks contributes to tropical deforestation by increasing demand for conversion of forest areas to biomass crop production. (WWF, 2006). Increased competition for land and water resources between biofuel crops and food crops also creates food security and other social issues for local communities (Muller, 2008).

Despite the potential environmental impacts associated with development of the bioenergy value chain, many authors (Zah et al., 2007, Muller, 2008, and WWF, 2006) note that biofuels can be developed sustainably and become important sources of energy for local communities while reducing greenhouse gas emissions. In general, the desirability and sustainability of bioenergy as an alternative to petroleum depends largely on how it is developed. It is imperative that some form of comprehensive Life-Cycle Analysis (LCA) and environmental impact assessment be conducted for the bioenergy value chain to determine the appropriate technologies and direction for bioenergy development (Sharlemann and Laurance, 2008, Zah et al., 2007, Muller, 2008).

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2 Second generation biofuels include those made from the breakdown of plant cellulose or lignin
This chapter of the Bioenergy Master Plan identifies and evaluates the potential environmental impacts that could occur from the production of biofuels along the value chain, including feedstock production, feedstock logistics, conversion, biofuel distribution, and end use in Hawaii. The first section is a discussion of the Objectives and scope of work of the study. The second section on Findings is divided between an overview discussion of the general environmental issues associated with the development of bioenergy and an analysis of the potential environmental impacts associated with the bioenergy value chain in Hawaii. The last section of the chapter includes recommendations for the Bioenergy Master Plan on managing environmental issues of bioenergy in Hawaii.

4. Objectives

Since the technologies, crops, methods, locations, and timing for development of the bioenergy value chain in Hawaii are not specifically identified and may change over time as technologies emerge, the objective of this chapter of the Master Plan is to provide a general assessment of the broad environmental impacts\(^3\) and issues related to bioenergy development in Hawaii and to establish a framework for assessing specific impacts as technologies and projects are proposed and implemented. Future Life-Cycle Analysis of biofuels processes and environmental impact assessment\(^4\) of individual projects will be necessary in order to create an environmentally sustainable bioenergy industry that meets the State’s goals of reducing greenhouse emissions and increasing energy security.

5. Scope of Work

The scope of work of this chapter includes:

1. Identify appropriate stakeholders, technical experts, and information sources throughout the state.
2. Conduct meetings and surveys with stakeholders, and research and analysis to:
   a. Document the range of potential environmental impacts that are applicable to transitioning Hawaii to a bioenergy economy;
   b. Identify parameters that will serve as indicators of the potential impacts identified in 2 a and how they can be monitored;
   c. Other considerations relevant to the topic.
3. Based on work conducted per item 2 above:
   a. Conduct analysis of environmental impacts, related to development of a bioenergy industry;

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\(^3\) The term “environmental impacts” was interpreted by the authors to include socio-economic and cultural impacts. The inclusion of these associated impacts in environmental impact analysis is standard practice under the National Environmental Policy Act (NEPA) and Chapter 343, Hawaii Revised Statues.

\(^4\) Not all bioenergy projects may be required to complete federal and state Environmental Assessments (EA) or Environmental Impact Statements (EIS). The National Environmental Policy Act (NEPA) and Chapter 343, Hawaii Revised Statues have specific triggering requirements for preparation and processing of EAs and EISs for proposed actions. The authors do not imply that the legal processes included in those statues are, or are not required, for all bioenergy development projects in Hawaii.
b. Provide analysis of ways to reduce the likelihood of negative environmental impacts and increase the likelihood of positive environmental impacts;
c. Identify methods to facilitate development of a bioenergy industry using an approach that is sensitive to impacts; and
d. Conduct other related work to further support the objectives of this Task.

The majority of activities completed for the scope of work were related to research and analysis. Broad research and analysis was completed on the environmental aspects of bioenergy development throughout the world and the United States.

To complete the scope of work for this chapter, various activities were completed in 2009. A stakeholder meeting with two break-out sessions was completed on April 2, 2009. During this meeting stakeholders were asked to give their impressions and views on the potential environmental impacts of bioenergy development in Hawaii. Individual meetings were also held with selected stakeholders from the environmental and business communities to clarify some specific issues. Stakeholder input was used in the development of recommendations. The environmental impacts breakout section notes are included as Appendix 1. Highlights of the responses are provided below.

Question 1. What do you think are the most critical environmental issues related to bioenergy development in Hawaii?

Responses to Question 1. included discussions on (1) the environmental impact assessment process and the uncertainty it may present to the bioenergy development process, (2) land use change and competition for scarce agricultural land between biofuels feedstock crops and small farmers, (3) risks of biofuels feedstock crops being invasive species, (4) impacts to water quality and water use from biofuels, (5) general regulatory issues, (6) crop abandonment, and (7) environmental justice regarding locating of bioenergy facilities.

Question 2. What would be the best way to continue the community discussion on the environmental issues as the Master Plan is developed in the next 6 months? And in the next 2-3 years should this planning effort continue?

In responses to Question 2. stakeholders identified a desire to (1) develop a Hawaii energy forum for discussing bioenergy, (2) use existing websites, (3) develop a public education outreach and extension effort, (4) conduct comprehensive review of permitting issues related to bioenergy.

6. Environmental Issues

The evaluation of the environmental impacts of bioenergy and biofuel development has principally focused on the potential benefits to climate change from the reduction in greenhouse gases offered by a reduction in the use of fossil fuels. This approach is too narrow because of the array of direct and indirect environmental impacts associated with the various components of the bioenergy value chain. The following section describes
the factors involved in assessing the potential environmental impacts of bioenergy development and discusses how they may be manifested in Hawaii.

6.1 Net Energy Balance

The reduction in use of fossil fuels for energy is regularly sited as one of the reasons for developing bioenergy technologies. Biofuels can replace fossil fuels in a wide array of electrical generation and transportation fuel uses. Despite bioenergy being a “renewable” energy source, it does require the consumption of fossil fuels in the various phases of the value chain. This includes energy for growing seeds, powering farm machinery and buildings, producing fertilizers and pesticides, processing and conversion of biomass to fuels, transporting feedstocks and biofuels, storage of biofuels, and end use distribution. To be a viable alternative to fossil fuel from a net energy perspective, a biofuel should provide a net energy gain.

The analysis and debate regarding the benefit of biofuels in the displacement of fossil fuel is focused on the net energy balance of the various biomass crops and the amount of nonrenewable energy required in the production value chain of the biofuel. There is, however, considerable variability in the methods used to determine the net energy balance of biofuels and a general lack of consensus among proponents and detractors on how to evaluate each bioenergy technology.

Since, one of the goals of State is to reduce Hawaii’s reliance on imported petroleum then the individual proposed bioenergy technologies in Hawaii should be evaluated for their net energy balance.

6.2 Greenhouse Gas Reduction

A major promise of bioenergy development is the potential reduction in greenhouse gas emissions provided by the reduction in use of fossil fuels. Biofuels can provide energy that displaces fossil fuels for both electrical generation and transportation uses. Bioenergy crops also can reduce or offset greenhouse gas emissions by directly removing carbon dioxide from air as they grow and storing it in crop biomass and soil. In addition to biofuels, many biomass crops generate co-products, such as protein for animal feed or corn oil that further reduce the need for fossil fuels.

Recent scientific studies have revealed that different biofuels vary widely in their greenhouse gas balances when compared to petroleum products (Farrell et al., 2006, Scharlemann and Laurance, 2008, Farigone et al., 2008). Depending on the methods or inputs used to produce the feedstock and process the biofuel, some technologies can even generate more greenhouse gases than do fossil fuels. For example, nitrous oxide, a greenhouse gas with global-warming potential around 300 times greater than that of carbon dioxide, is released from nitrogen fertilizers that are used in producing some biofuels. Greenhouse gases also are emitted at other stages in the value chain and in the production of fertilizers, pesticides and fuel used in farming and during chemical processing, transport and distribution, and final use. The effective use of co-products
from bioenergy conversion and processing is critical to establishing a positive net greenhouse gas balance. However, marginal markets for some co-products may reduce the overall greenhouse gas benefit of some biofuels.

Another contributing factor to the greenhouse gas balances of biofuels is the land use changes brought on by their development. As a result of increased demand for biofuels such as corn, palm oil, and soy, more lands are being placed in biofuel crop production. This increased demand for land displaces traditional food crops and increases the conversion of marginal lands to agricultural production for both biofuels and food crops (Searchinger et al., 2008, Fargione et al., 2008). Because existing land uses already provide carbon benefits in storage and sequestration, dedicating new lands to biofuels can potentially reduce greenhouse gases only if doing so increases the carbon benefit of using land for biofuels. Fargione et al. (2008) found that the conversion of native rainforests, peatlands, and grasslands to biofuels production creates a “biofuel carbon debt” by releasing 17 to 420 times more carbon dioxide than the annual greenhouse gas reductions that biofuels would provide by displacing fossil fuels. Searchinger et al. (2008) also find that by including land use change in their greenhouse gas balance model, corn-based ethanol nearly doubles greenhouse gas emissions over 30 years, while switchgrass, grown on converted corn lands, increases emissions by 50%. The substantial increase in greenhouse gas emissions for biofuels produced on converted crop lands highlights the value of biofuels made from waste products such as cellulosic ethanol (Searchinger et al., 2008).

It is important to establish accounting methods that evaluate the greenhouse gas balances for individual biofuel value chains in Hawaii to understand if they will provide a net positive greenhouse gas balance. This evaluation should include analysis of the possible conversion to biofuels production of existing sugarcane lands, fallow prime agricultural lands, forested lands, lands currently in diversified agriculture, or those lands in cattle production.

6.3 Land Use

Bioenergy development generally requires significant tracts of agricultural land to produce the quantities of feedstock needed for biofuel production. Consequently, there are various potential impacts to land use in Hawaii from the proposed development of bioenergy to meet the 20% alternative fuel standard. The Bioenergy Master Plan focuses on availability and potential development of prime agricultural lands. El-Kadi and Ogoshi (2009) find that approximately 53,246 acres may be devoted to bioenergy production by 2030 based on an optimistic projection. This does not include the possible development of former plantation lands held by private landowners.

Economic incentives or subsidies for biofuels on state and private lands may shift current uses of agricultural lands toward the bioenergy market and displace current agricultural patterns. Existing large-scale sugarcane production on Maui and Kauai may be shifted to other biofuel crops. Prime agricultural lands also may be taken out of small-scale farming, cattle production, or other agricultural operations as demand for prime
agricultural land increases and the market for biofuels expands. This could result in a reduction in the number of acres of diversified agriculture in the state, reversing an expansion that began with the reduction in plantation agriculture statewide in the early 1990s. A reduction in local diversified agriculture and food crop production may result in increased petroleum use in order to import replacement food to the state. Furthermore, the state’s ability to produce local food and decrease its reliance on food imports may be diminished.

The shift to a bioenergy market also may cause land use conflicts centered around the development of biofuels on fallow agricultural lands that border newly developed residential areas. Recent urbanization on all islands has resulted in the residential development of more and more former agricultural lands. The reintroduction of intensive agriculture may cause conflicts between residents and agricultural activities. In addition, development of biofuels conversion plants and other supporting infrastructure in close proximity to newly developed residential areas also may cause conflicts between residents and these industrial operations.

Biofuels development also may be affected by the conversion of prime agricultural lands to non-agricultural uses. Since biofuel feedstocks are proposed to be grown on prime agricultural lands to attain maximum productivity and economic viability, the loss of prime lands could reduce the amount and diversity of available agricultural lands for their development.

6.4 Water Resources

Bioenergy development may adversely impact water resources in Hawaii because of the quantities of water required for some feedstock crops and the biofuel conversion process. Crops like sugar and banagrass would most likely require some form of annual irrigation, while other crops, including Leucaena and Eucalyptus, would be grown without applied irrigation (Keffer et al., 2006). Because different crops and production processes require varying amounts of water, it is difficult to quantify the potential water resource requirements. However, according to RMI (2006) in its evaluation of bioenergy development in Hawaii, it is unclear whether there are sufficient water resources to meet the potential future demand of a 20% alternative fuels standard. Currently, there is competing demand for scarce water resources in Hawaii between residential developers, small farmers, industrial agriculture, and others, making water a sought after commodity. Various high profile water rights cases have been decided in the courts recently because of the high demand for scarce water resources. The use of less water-intensive technologies or crops, such as those for cellulosic biofuels production, may help reduce the overall impact to water resources.

6.5 Water Pollution

Bioenergy development also has the potential to adversely affect both marine and fresh water quality. Intensive agricultural development for biofuels feedstock may increase erosion and sedimentation of streams and near-shore waters. The increased use of
agricultural chemicals, fertilizers and pesticides on currently fallow land also may affect water quality from the runoff of these chemicals to streams, near-shore waters and infiltration to groundwater. Furthermore, wastewater from the feedstock production, logistics, and conversion phases will need to be managed and processed before being released to the environment. Depending on the biofuel crops and processes used, wastewater can be minimized through its use in the development of co-products.

6.6 Invasive Species

Invasive species are introduced species that spread in a new geographic region, resulting in undesirable ecological, economic or human health consequences. Most invasive species are introduced deliberately or accidentally by people. Invasive species are recognized as a major ecological and economic issue worldwide, but they are of special concern in Hawaii.

Hawaii’s natural flora and fauna are composed of unique species, most of which are found nowhere else in the world. For example, more than 85% of Hawaii’s native plants are found only in Hawai‘i. Many of these native species are now rare or at risk of extinction. Hawai‘i has more Endangered and Threatened plants than any other state. Invasive species can compete with native species or cause disturbances that promote habitat degradation. Furthermore, invasive diseases, parasites and predators also harm native species. In addition to their ecological impacts, invasive species threaten Hawaii’s agriculture and forestry industries, and they potentially have negative consequences for tourism.

Although most introduced species do not become invasive, the introduction and promotion of non-native species for biofuel poses some risks. All plant species currently under consideration as biofuels are introduced species. Biofuels may pose particularly high risks of becoming invasive because many of the same traits that are desirable for biofuels, such as rapid growth and wide environmental tolerance, are also associated with invasiveness. Hawai‘i has a history of quickly importing and promoting plants that prove to be economically non-viable in cultivation; some of these have had enormous economic costs. A classic example was the importation and promotion of indigo, which never developed into a viable dye industry in Hawai‘i, but the plants quickly spread across Hawai‘i in the late 1800’s, becoming one of the worst weeds in agriculture at that time. Careful screening of plants for weediness or invasiveness can help minimize problems like this.

A weed risk assessment (WRA) system has been developed for Hawai‘i to evaluate risk of invasiveness in introduced plants. The WRA consists of a series of 49 questions addressing aspects of an introduced plant’s ecology, reproduction, growth, dispersal, harm to livestock and humans, and behavior as a weed in other parts of the world. Answers to these questions are used to generate a numeric WRA score. A high score (> 6) corresponds to a high risk that a plant will become a problematic weed.
Retrospective testing has demonstrated that Hawaii’s WRA system has an overall accuracy rate of around 80% in correctly identifying real invaders as high risk and non-invasive plants as low risk. The WRA for a candidate biofuel can be completed in one day at low cost (about 6 hours of research); therefore, using WRA to evaluate all biofuels is a sensible first step to screen out invasive plants. Many candidate biofuels have already been evaluated using the WRA system.

**Current candidate biofuel crops**

*Sugarcane (Saccharum officinarum and hybrids with S. spontaneum or S. robustum)*  
Weed Risk Assessment Score – 2 (low risk)

Sugarcane was an early Polynesian introduction to Hawai‘i, and it has been grown in large plantations for more than a century. Sugarcane is a perennial grass that is rarely found outside of cultivation. It rarely if ever, reproduces by seed in nature. Plants are persistent within abandoned plantations, but over time the abandoned plantations become increasingly dominated by other grasses such as Guinea grass (*Panicum maximum*) or woody species such as Leucaena. Sugarcane has a low WRA score, in part due to its low potential to spread and its lack of behavior as a weed around the world. All lines of evidence suggest that sugarcane poses little risk of becoming invasive in Hawai‘i.

*Domesticated food crops (corn, soybeans, peanut, sweet sorghum, cassava)*  
Weed Risk Assessment Score for *Manihot esculenta* (cassava) -- 3 (low risk)

Although most of these domesticated crops have not yet been formally screened by WRA, the fact that they are highly domesticated greatly reduces the WRA score. Furthermore, all of these species have a history of more than 100 years of cultivation in Hawai‘i, during which time they have not become invasive. These species pose little risk of becoming invasive.

*Banagrass (Pennisetum purpureum, possibly a hybrid with P. glaucum)*  
Weed Risk Assessment Score for *Pennisetum purpureum* – 16 (high risk)

Banagrass, is an extremely tall (4-7 meters) and densely-growing grass originally from Africa. Banagrass is often referred to as *Pennisetum purpureum* in agronomic literature, but it may also refer to a hybrid between *P. purpureum* and *P. glaucum*. In order to properly assess the potential invasiveness of banagrass in Hawai‘i, the genetic constituency of the plants being proposed for biofuel use needs to be clearly determined, and the proper scientific name should always accompany the name “banagrass”. In the absence of information to the contrary, it is assumed that banagrass is ecologically the same as Napier grass (*Pennisetum purpureum*). Napier grass was first documented from Lanai in 1922, where it was planted at the Agricultural Experiment Station. Field trials with banagrass/Napier grass have continued on several islands, but at a small (experimental) scale and at relatively few sites. Banagrass/Napier grass has become naturalized in Hawai‘i, where it is prominently seen along roadsides and around pastures, mainly at wet sites. A major concern is that this massive grass could become established...
along streamsides, clogging waterways, promoting flash floods, and affecting water delivery. The weed risk assessment recognizes banagrass/Napier grass as a serious weed in other parts of the world, including Florida, which shares many invasive species with Hawai‘i. Although banagrass/Napier grass is already present in Hawai‘i, large scale plantings can be expected to substantially increase sites of invasion in Hawai‘i.

**Eucalyptus** (*Eucalyptus grandis, Eucalyptus urophylla, hybrids, and other Eucalyptus species*)

Weed Risk Assessment Scores, *Eucalyptus grandis* – 11 (high risk)

Eucalyptus *urophylla* – 4 (low risk)

More than 400 species of Eucalyptus are known. Almost all of them are native to Australia, and 100 or more species have been widely planted for forestry around the world. They are rarely invasive. In Hawai‘i, Eucalyptus have been popular trees for forestry since the early 1900s, with 30 or more species now found in plantations. It is not uncommon to find seedlings in the vicinity of plantings, but as yet none of the Eucalyptus in Hawai‘i can be classified as important invasive species. Nevertheless, *Eucalyptus grandis*, which is one of the popular biofuel species, received a WRA rating of ‘high risk’. This species has a high WRA score primarily based on its invasive behavior in South Africa. In South Africa, *E. grandis* invades along river courses. This is a particular concern in drought-prone regions of South Africa because Eucalyptus have been shown to use more water than native vegetation, reducing the water available for human needs. Large plantations of *E. grandis* are already established in Hawai‘i, but most of these are recent plantings, so there has been little time to judge invasiveness within Hawai‘i. For the most part, Hawai‘i lacks riverine habitats like those susceptible to *E. grandis* invasion in South Africa, and this may decrease the risk in Hawai‘i, but this species should be monitored.

**Leucaena** (*Leucaena leucocephala*)

Weed Risk Assessment Score – 15 (high risk)

Leucaena is a fast-growing small tree that harbors nitrogen-fixing bacteria in its roots. This adaptation allows Leucaena to thrive in poor soils. Leucaena is also drought tolerant, making plantings feasible at many leeward sites, even without irrigation. Leucaena has been present in Hawai‘i for more than 150 years, and it has been widely planted. It is found growing wild in dry habitats on all the main Hawaiian Islands, and it is often considered a problematic weed of natural areas, capable of forming dense stands. Leucaena also invades pastures, but it is generally considered palatable to livestock. The weed risk assessment identifies Leucaena as serious weed in various places around the world, including Hawai‘i, where it can form dense thickets. Leucaena also produces long-lived seeds, which promote the plant’s persistence in the wild. In Hawai‘i, Leucaena has probably already reached its full range of invasion. Its abundance seems to be regulated by fire-return intervals in dry habitats. Because of its extensive spread in Hawai‘i, additional plantings for biofuel may have limited impacts. However, if new Leucaena cultivars are considered, then the risk should be carefully re-considered, as new cultivars
may differ ecologically, potentially resulting in greater invasiveness and new unintended impacts.

**Jatropha (Jatropha curcas)**
Weed Risk Assessment Score – 17 (high risk)

Jatropha is a small, drought tolerant tree grown for its oil-rich seeds. It is a relative of *kukui* (*Aleurites moluccanus*), a much larger tree common in Hawai‘i that also produces oil-rich nuts. Jatropha has been present in Hawai‘i, probably since the early 1900’s; however, plantings have been very small in scale, providing little opportunity for these plants to spread. Nevertheless, Jatropha is now found in wild populations on the south slope of Haleakala, Maui, as well as escaped from small-scale plantings on the island of Hawai‘i, and to a lesser extent on O‘ahu. The WRA recognizes Jatropha’s status as a noxious weed in Australia, where it is banned from cultivation. In South Africa, Jatropha can be planted only with a research permit, due to concerns about its environmental and economic impacts. This plant forms dense stands in natural habitats, and it has toxic seeds. Accidental poisonings have been reported in various parts of the world; the fruits are reportedly attractive to children. Planting of Jatropha as a biofuel is likely to increase the rate and extent of Jatropha invasion in Hawai‘i, and this risk should be carefully considered prior to adopting Jatropha for biofuel production.

**African Oil Palm (Elaeis guineensis)**
Weed Risk Assessment Score – 10 (high risk)

African oil palm is one of the most common sources of palm seed oil, which is used in various types of food products. Therefore, plantations of African oil palm already exist in tropical zones on all continents, as well as on many tropical islands. In Hawai‘i, African oil palm occurs primarily in botanical gardens, although small-scale research plantings have also been undertaken. The weed risk assessment indicates a high risk of invasiveness, partly due to its production of large numbers of bird-dispersed fruits, which are liable to be carried into natural habitats. African oil palm has also been reported as naturalized at a few sites around the world. This is not surprising, considering the scale of plantings that have occurred; rather, what is striking from the WRA is that there is no documented evidence of negative impacts of African oil palm despite it having been distributed around the world for at least a century and planted in very large quantities. Considering the global history of African oil palm, naturalization may be expected in Hawai‘i if it is grown at a large scale, but impacts of naturalization may be difficult to document.

**Algae**
Much of the biofuel research today targets microalgae growing in artificial tanks or closed system cultures. The weed risk assessment developed for land plants is not adaptable to single-celled algae because traits or features of single-celled organisms are different from those of large terrestrial plants. Nevertheless, risks posed by these algae should be assessed by examining at least two general issues, 1) likelihood that alga will escape into nature; this may depend on the circumstances of culture or harvesting, and 2)
the potential impacts on aquatic habitats if the alga escapes; this could be judged partly from impacts observed in other parts of the world. If the micro-alga is already naturally occurring in Hawai‘i, then its cultivation as a biofuel an artificial or closed system would probably pose little risk.

Other invasive species risks
While most species currently under consideration as biofuels are already present in Hawai‘i, there will likely be a need to import new plant material. Importations may include new plant species or new genetic stock of species already present in Hawai‘i. In either case, importation of new plant material involves risks of unintentionally importing diseases and other plant pests. In Hawai‘i, strict quarantine procedures are already developed for importation of grasses. Establishing similar quarantine procedures for all imported biofuel materials would help protect the industry while also reducing risks to agriculture and native ecosystems.

6.7 Soil Quality

Intensive feedstock cultivation may also adversely impact soil quality. Biomass crops pose a challenge to good soil management because the plant material is often completely harvested leaving little organic matter or plant nutrients for recycling back to the soil. Intensive use of fertilizers and pesticides also may negatively impact soil quality. However, conversion of crop lands from annual crops to fast-growing woody crops or perennial herbaceous crops progressively increases the soils’ organic matter content (Cook and Beyea, 2008). Also, a transition to perennial crops from annual crops may reduce the use of fertilizers and pesticides, depending on the crops and what uses they displace (Cook and Beyea, 2008).

6.8 Air Quality

Bioenergy development may have both positive and adverse affects on air quality through the value chain. During feedstock production air quality may be adversely affected as areas come under cultivation and soil erosion is increased, affecting neighboring communities. Increased vehicular traffic during the logistics phase of the value chain, emissions during conversion processing of biofuels, and traffic during distribution of end product may contribute to increased air emissions. In particular, the processing of biofuel feed stocks can affect local air quality with carbon monoxide, particulates, nitrogen oxide, sulphates and volatile organic compounds released by industrial processes.

Analysis of the potential impacts of bioenergy technologies on air quality and health by Hill et al. (2009) show that a shift from gasoline and the current generation of food-based ethanol biofuels to cellulosic ethanol will have health benefits to society of comparable importance to the climate change benefits of a reduction in greenhouse gas emissions. The advantages to air quality in the form of a reduction in PM$_{2.5}$ from a shift to cellulosic ethanol are directly tied to the source of land used to produce the biomass crops and the potential indirect impacts from land use changes (Hill et al., 2009)
6.9 Residue Management

Feedstock production, feedstock logistics, and the biofuel conversion phases of the bioenergy value chain generate residues that must be managed. Some residues can be used and marketed as co-products or by-products, including distillers grains and glycerin. Distillers grains are routinely used in animal feed. The market for biofuel co-products in Hawaii is not clear. Residue products from the various processes that are not used or shipped out of state will need to be disposed of locally. This may cause adverse impacts to already taxed local landfills.

Some forms of biodiesel are derived from waste vegetable oil collected from various restaurants and other sources. Waste oil is processed into biodiesel and marketed for use in transportation and electrical energy production. Currently, Pacific Biodiesel has the capacity to produce approximately 1,500,000 gallons of biodiesel annually at its plants in Honolulu and Kahului for use in local transportation (National Biodiesel Board, 2009).

6.10 Socio-economic and Cultural

Social and cultural issues are routinely included in environmental impact assessment of proposed actions to assist in understanding the broader implications of those actions for Hawaii and its local communities. Of particular importance is evaluating how potential environmental impacts and use of resources may affect Native Hawaiian cultural issues and rights.

Full-scale development of bioenergy to the 20% alternative fuel standard may have significant social, economic, and cultural implications for Hawaii. The reemergence of intensive agricultural activities for feedstock production will produce new jobs and training requirements for a portion of Hawaii’s labor market. With the virtual demise of plantation agriculture, there may no longer be a reliable supply of agricultural workers for feedstock production on the various islands. Bioenergy may spur employment and renewed community development in certain areas.

Introduction of bioenergy production also may displace existing agricultural activities like small farming or cattle-raising on which some communities are based. This may cause social conflicts between the proponents of bioenergy and these existing activities. Displacement of existing small farms and ranches may cause a reduction in locally grown truck crops or meat, causing an increase in prices for local produce. However, the potential for development of various co-products may support other local agricultural enterprises.

Development of bioenergy projects will require the construction and operation of conversion facilities and related infrastructure. Facilities may be proposed for development in communities that are averse to having agricultural and industrial biofuels production in their areas. Increased traffic, noise, and air pollution from all phases of development of the value chain may cause adverse impacts to local communities. These adverse impacts may cause varying degrees of social conflicts.
Lastly, the potential demand for water and land from bioenergy development may cause significant impacts to existing communities that rely on these resources or border potential biofuels production crops or facilities. In particular, impacts to Native Hawaiian cultural practices from the development of the bioenergy value chain need to be evaluated as projects are proposed. Water rights as well as ceded lands issues will most certainly be affected by the potential use of large quantities of water and State lands.

It is difficult to evaluate the potential social and cultural issues related to bioenergy development without concrete development plans. In general, it will be important for proponents of bioenergy to establish a continuous dialogue with community stakeholders to minimize potential conflicts.

6.11 Transnational Environmental Issues

Despite Hawaii being one of the most isolated areas in the world, any development of bioenergy in Hawaii will be effected by, and potentially may affect, international biofuel and agricultural markets and local environmental conditions. The introduction of biofuels crops and production in the United States has affected land use in other parts of the world. This is exemplified by the case of increased corn-ethanol production in the United States whereby farmers were incentivized to shift from soybeans, wheat, and other crops to meet the demand for corn. The subsequent rise in prices for soy beans and other agricultural commodities induced an indirect increase in soy bean production in Brazil and conversion of marginal lands and rainforest to agricultural production (FAO, 2008).

The possible importation to Hawaii of finished biofuels or feedstock for use by end users also may cause direct environmental impacts and land use changes in those countries that supply the finished biofuels or feedstock. Currently, Hawaiian Electric Company (HECO) proposes to import Malaysian palm oil from a provider that certifies the environmental sustainability of the production process in Malaysia. The use of the finished biofuel by HECO or others may help create the end market for biofuels in Hawaii and thus should help to induce local production of suitable biofuels to replace imported products. While the certification of the imported finished biofuels helps reduce environmental impacts in Malaysia where these fuels are produced, the increase in the international market demand for finished palm oil may induce farmers to convert sensitive habitat or marginal lands to biofuels production in other areas.

There are direct and indirect land use changes resulting from biofuels development that must be accounted for in the overall analysis of environmental impacts. Development of a bioenergy economy in Hawaii, that relies at least in part on imported biofuels, may create further market demand internationally and require that local producers be able to produce biofuels competitive with international market prices.
7. Value Chain Impact Analysis

The following section includes brief descriptions of possible actions and activities to be undertaken under each phase of the bioenergy value chain in Hawaii and a summary of the possible environmental impacts.

7.1 Feedstock Production

*Types of Actions and Activities:* Feedstock production includes the growing of biomass crops. There are a diversity of crops and techniques for growing feedstocks, and these generally require land, water, some external energy source, fertilizers, pesticides, and labor.

*Types of Environmental Impacts:* Agricultural production of feedstocks has many potential environmental impacts. The potential impacts of feedstock production include greenhouse gas sequestration, land use changes, water use, water pollution, waste management, soil erosion and degradation, invasive plant introduction, air quality degradation, and socio-economic and cultural impacts. There may be conflicts over land and water use. Feedstock production, to the extent it may rely on imported oils as a transitional strategy, also may cause direct and indirect environmental impacts to other areas on the mainland or internationally that are affected by the international markets for bioenergy.

7.2 Feedstock Logistics

*Types of Actions and Activities:* Feedstock Logistics involves the harvesting, transportation, and storage of biofuel feedstocks. This generally requires land for storage of feedstock and vehicles. External energy sources are required for development and operations.

*Types of Environmental Impacts:* The potential environmental impacts may include land use changes for storage of feedstock and baseyarding of vehicles, soil erosion and air quality degradation during harvesting, and the socio-economic and cultural impacts.

7.3 Conversion

*Types of Actions and Activities:* Conversion involves the processing of feedstocks into biofuels. It represents a wide range of processes for production of biodiesel, ethanol, or other biofuels. Generally, conversion is the more industrial phase of the value chain and requires the greatest input of external energy sources. Water and chemicals also are required in this phase for processing of feedstocks to biofuels.

*Types of Environmental Impacts:* Since the conversion process phase is the most industrial, many of the potential environmental impacts are related to waste management and pollution. Air quality degradation is a potential impact from the processing of biofuels. There may be socio-economic and cultural impacts to local communities from
the development of industrial facilities in some areas. While some jobs and economic activity will be created, there may be conflict over development and operations of these facilities.

7.4 Distribution

*Types of Actions and Activities:* The Distribution phase of the value chain includes the transportation of finished biofuels to end users. This phase will involve development and use of some transportation infrastructure including ports, pipelines, tanker trucks, and storage facilities. Land and external energy resources will be required for the development and operation of this infrastructure.

*Types of Environmental Impacts:* The potential environmental impacts from the Distribution phase will be similar to other transportation actions and activities. There may be construction of improved port facilities, pipelines, baseyards, and storage facilities to accommodate the movement and storage of biofuels. Employment opportunities will be created. There may be some additional socio-economic and cultural impacts from the development of new facilities in ports and on other lands. This may result in some conflicts over land use.

7.5 End Use

*Types of Actions and Activities:* The End Use phase of the value chain involves the use of biofuels for transportation uses and electrical energy generation.

*Types of Environmental Impacts:* The environmental impacts of the End Use phase include the reduction in use of fossil fuels and greenhouse emissions through the use of biofuels.

8. Recommendations

As various authors have found (Zah et al., 2008, Scharlemann and Laurance, 2008, Hill et al., 2009), not all biofuels are beneficial when the full extent of their environmental impacts are assessed. There is a clear need to evaluate the costs and benefits of reducing the use of imported fossil fuels and greenhouse gas emissions, as well as the other environmental aspects of the process. The environmental, social, and cultural impacts of bioenergy development need to be evaluated at the local level in Hawaii as aspects of the value chain are defined for proposed projects and technologies. Particular attention should be focused on the feedstock portion of the value chain since most of the potential environmental and social impacts from bioenergy development occur during this phase. In particular, the potential risks to Hawaii from invasive species are critical. It should be noted that many of the potential environmental impacts from bioenergy are the same as those of traditional agriculture. The State of Hawaii needs to be selective in the crops and technologies that may be supported with subsidies and tax benefits, keeping in mind
that second generation biofuels, including cellulosic ethanol and algae, show great potential to reduce many of the adverse environmental impacts.

The potential impacts to agricultural land use practices from biofuels development also need to be examined further. Introduction of biofuels subsidies and incentives will increase competition for use of prime agricultural lands between biofuels proponents, small farmers, ranchers, and non-agricultural developers. The State needs to examine the balance between food security, fuel security, and development in Hawaii and reassert its priorities for prime agricultural lands.

The socio-economic and cultural impacts from bioenergy also need to be evaluated along with the biophysical. The potential impacts to local communities should be evaluated using a community-based approach where a long-term dialogue is initiated with local communities and stakeholders to help define potential impacts and mitigation measures for affected areas.

Through a rigorous environmental assessment and life-cycle analysis process, and the establishment of sound policies and incentives, a more sustainable bioenergy industry may be developed. The State of Hawaii should evaluate all the potential environmental issues, including net energy and greenhouse gas balances, potential shifts in agricultural uses, air quality impacts, water use issues, risks from invasive species, and possible social and cultural impacts, prior to commencing with bioenergy development in the Hawaii. The following are specific recommendations for evaluating and mitigating potential environmental impacts from bioenergy development in Hawaii.

1. **Environmental Impact Assessment** – As specific proposals are put forward for development of aspects of the bioenergy value chain, environmental assessments or environmental impact statements should be completed pursuant to the State of Hawaii environmental review law (Chapter 343, HRS) and the Department of Health Title 11-200 administrative rules governing the review process. It should be noted that not all bioenergy projects may trigger Chapter 343, HRS due to their proposed locations, land ownership, and/or funding.

   Environmental assessments and impact statements should include evaluations of the potential social, economic, and cultural impacts associated with the proposed projects, as required in the Title 11-200 administrative rules for the environmental review process. Assessments should strive to include analysis of how specific proposed projects for bioenergy development in Hawaii will effect and be affected by international market conditions. This analysis will give transparency to the potential indirect and direct environmental impacts of biofuels development in Hawaii.

2. **Life-Cycle Analysis (LCA)** – Life-Cycle Analysis (LCA) is the cradle to grave systems approach for examining technology and systems. LCA should be used to examine the specific technical aspects of any proposed biofuels value chain, the crops, energy requirements, emissions, direct and indirect land use changes, water
use requirements, wastes, logistics, conversion technology, distribution, and end use to determine the net energy and greenhouse gas balances of the biofuel. This process is being used nationally and internationally to evaluate bioenergy development and could be employed for analysis of local conditions and permitting.

The State should establish requirements for LCA based on Hawaii’s specific environmental conditions, goals and needs. The State also should establish guidelines for conducting LCA including certification of LCA methodologies. LCA should be used as an integral component in a biofuels certification process.

3. Conservation Agriculture – Since most environmental impacts from bioenergy development are found in the feedstock production phase, the State should require appropriate conservation agriculture practices for biofuels feedstock production. This would help reduce water consumption, use of pesticides and fertilizers, and pollution.

4. Weed Risk Assessment (WRA) – Weed Risk Assessment (WRA) should be required for all candidate crops for biofuel production. Since Hawaii has sensitive natural resources that are susceptible to invasive species, the State should establish criteria for restricting certain candidate crops that may have the greatest potential for harm. It may also want to limit introduction of certain crops from areas near sensitive habitats depending on the individual characteristics of the candidate crop.

5. Examine the Issue of Agricultural Land Use and Biofuels – The State should commission a study to examine the potential issues related to agricultural land use and biofuels. The potential impacts to local agriculture from an introduction of large-scale biofuel development may be significant. Of particular importance is the potential loss of local food-crop production as prime agricultural lands are shifted to biofuels and other non-agricultural uses.

The study should examine how existing agricultural practices and uses of land, including small farming and ranching, may be impacted by the introduction of incentives and subsidies for biofuels. This should include an analysis of food security and fuel security issues in Hawaii. The study should also examine how the conversion of prime agricultural lands to non-agricultural uses may affect biofuels development and long-term viability.

6. Encourage Use of Existing Infrastructure – To minimize the potential environmental impacts from the development of new infrastructure needed to support bioenergy, the State should encourage the use of existing conversion facilities, pipelines, and other infrastructure where applicable.

7. Community-Based Bioenergy Working Group – Many stakeholders expressed concern about the lack of information regarding environmental issues and the
State’s plan for bioenergy development. Many requested a forum to exchange information. The State should establish a community-based working group with representatives from various stakeholders including, but not limited to, representatives from State of Hawaii Departments of Agriculture; Business, Economic Development and Tourism; Land and Natural Resources; Attorney General; bioenergy entrepreneurs; large landowners; small farmers; environmentalists; Native Hawaiian groups; the power industry; etc.

This forum would be useful for creating community dialogue and understanding about bioenergy development and environmental issues in Hawaii. It could also be used as a tool for gathering information for social and cultural impact assessment.

8. **Biofuel Certification Program** – To safeguard Hawaii’s unique native eco-systems and culture, and support sustainable biofuels development, the State should explore the possible development of a certification program for biofuels. Many localities are proposing that biofuels meet certain mandated targets or minimum goals to receive subsidies, permits, and government recognition. A certification program in Hawaii should include various sustainability requirements related to attaining specific net energy and greenhouse gas balance goals, ensuring protection against invasive species, establishing water, soil, and land conservation, protection of local food supplies and farming, protection against transnational environmental issues and indirect impacts to land use, and other social and cultural issues.

It should be noted that certification programs are difficult to employ and may, if too unwieldy or burdensome, constrain the development of the local biofuel industry in Hawaii. If employed, certification should be targeted at specific local problems and tailored to meet specific sustainability goals established by the Legislature.

Due to the complexity of the issues, the State should commission a separate study to examine biofuels certification for Hawaii. The study should include analysis and recommendations for sustainability requirements, implementation and timing guidelines, requirements for LCA and methodologies, and the specification of departmental permitting responsibilities. A central component of the study also should be the analysis of the various certifying methods including government run certification programs, preliminary certification for “First-Movers”, voluntary certification, and third-party certification. Optimally, certification of any sort should not add to the duration of the overall permitting process. Efforts should be made to coordinate existing permitting and disclosure processes and reduce or eliminate redundancies.

Optimally, a certification program should be established prior to the development of new subsidies for biofuels in Hawaii. However, due to the State’s desire to encourage rapid development of bioenergy there may need to be some discussion
about creating initial screening processes and preliminary certification to help first movers with “shovel-ready” projects or demonstration projects. If a “First-Movers Program” for preliminary certification was established, any participating programs should be required to complete a full and timely certification and LCA as part of their final permitting/compliance. Strict precautions would need to be taken in a preliminary certification process to safe-guard against invasive species and any other irreversible commitment of resources that may be proposed by a project under a “First-Movers Program”.
9. References


Session 1

1. **What do you think are the most critical environmental issues related to bioenergy development in Hawaii?** Participants were asked to brainstorm their ideas. The participants then grouped similar ideas. They were asked to identify the 3 most critical issues.

**EIS and Environmental Regulations**
- Passage of more stringent legislation relative to environmental issues potentially stalls the process for bioenergy development.
- Our group is interested in business aspects of bioenergy development. How would environmental issues be reconciled with beneficial economic issues? EIS in place to protect interests. It’s a paradox.
- EIS can balance out the process
- Are the guidelines clear for EIS?
- There is uncertainty in the time necessary to do all the environmental assessments and it is difficult to make all stakeholders comfortable. It means greater potential investment risk for bioenergy ventures.
- The uncertainty discourages investment.
- issues related to EIS statements

**Land Use Priorities**
- There is competition between bioenergy versus food production. Bioenergy is highly subsidized.
- How can we address the EIS without it becoming an obstacle?
- Is there a concern regarding who gets priority for things like subsidies?
- Priorities over land use – e.g., public lands; property for planting
- This falls under competing land uses specific to public lands
- How do we ensure this is a continuing process?
- Should there be a higher priority for bioenergy? Industry vs. small farmers?
- Land and water use are competing priorities for all lands.

**Invasive Species**
The State has a weed risk assessment. It should be part of the evaluation. In a recent study, “Assessing Biofuel Crop Invasiveness,” a case study by Christopher Buddenhagan, Charles Chimera, and Patti Clifford, more than half are more likely to become invasive.

- Do you know if the top 5 on the bioenergy list (from handout in packet) are invasive?
- Any review/recommendations go through State assessment.
- Invasive species - Weed Risk Assessment is part of the Environmental Impact process.

2. **What would be the best way to continue the community discussion on the environmental issues as the Master Plan is developed in the next 6 months? And in the next 2-3 years should this planning effort continue?** Participants were asked to brainstorm their ideas. The participants then grouped similar ideas.

### Use Existing Forums
- Use existing technology like the Hawaii Natural Energy website (a web based resource for the community)
- Environmental-focused groups and forums
- Create links to agencies (the Hawaii Invasive Species Council has links) and facilitate access to information

### Communication Plan Should include:
- In Hawaii people like community meetings
- Someone needs to organize a communication strategy
- Site link, social chat rooms, and community meetings
- Business Roundtable – you need a strategic communication plan
- Allow for balance in communication; public, clear decision making opportunity
- Centrally organized – names, email, list serve
- Include Q and A, talking points, FAQs
- General public audience
- Complicated issues made easily understood
- Balance is important. It needs to be very organized, but keep it diverse.
  Everyone wants information. It is human nature to seek an edge.
- Need to rely on the corporate sector to get the message out
- I can’t imagine balance in 6 months, but you can distribute good information
- Small farmers need their information in their language. High speed internet is not always accessible for them.
- CTAHR (College of Tropical Agriculture and Human Resources) Cooperative Extension SVC can help bring small farmers in (field workers)
- Write up a draft to react to and gather feedback

### Permitting Concerns
- We need to conduct a comprehensive review of the permitting process. Are the lags at the county level or state level?
- Currently, all agencies – how to create more certainty about permitting
• Independent review could give us idea of what’s short and long term realities tied to environmental issues

Other
Funding issues?

Session 2

1. What do you think are the most critical environmental issues related to bioenergy development in Hawaii? Participants were asked to brainstorm their ideas. The participants then grouped similar ideas. They then voted to identify which group was the most critical Environmental issue.

Invasive Species (5 votes)
• Introduction of invasive species
• 2 to 5 biofuels are more likely to be invasive
• We say we are helping solve the invasive species problem, but the reality is many areas are inaccessible and are not an economic option

Water and Land impacts; secondary environmental impacts (5 votes)
• Hawaii uses billions of gallons of gasoline – for every gallon of ethanol, you need 5 – 6 gallons of water
• We have competing land and water use, such as growing crops for food versus fuel
• If chemicals are used it can impact our water quality
• International studies on biofuels report that the high expectations aren’t necessarily being met
• There is a good return, but waste products impact the environment
• What about harvesting? What are the negatives? It adds jobs. What is the environmental impact?
• Reef impacts with erosion through intensive agriculture

Regulatory Issues – water (1 vote)
• In the case of micro algae – what happens if regulation on emissions, ground level, permitting, technical sides?

Production of jobs (1 vote)
• Biofuels could provide new jobs

Crop abandonment (0 votes)
• From the landowner perspective, what happens after a crop is planted? What if it doesn’t pan out? What’s the consequence?
• If biofuels become invasive, then crop abandonment occurs
• Who is responsible for crops that don’t stay put?
• Costs are passed on to the community

Environmental Justice (0 votes)
• Environmental justice has to be considered in the location of processing plants

2. What would be the best way to continue the community discussion on the environmental issues as the Master Plan is developed in the next 6 months? And in the next 2-3 years should this planning effort continue? Participants were asked to brainstorm their ideas. The participants then grouped similar ideas.

Community Dialog
• Have a community dialog on each island
• Reach out to the average public and communicate how it will impact them
• Actively seek interested people as opposed to “passively” interested – “proactive” outreach
• Have a Hawaii Energy policy forum
• Publicize via a website – increase public awareness (e.g., DBEDT website)

Public Education
• Education – go to schools and educate kids and they will educate their parents
• A landowner can plant whatever s/he wants. They are not regulated. Large landowners and farmers need education and training.
• Put together an educational symposium for public awareness and training.