Hawaii Biofuels Summit
Briefing Book

August 8, 2006

I. What are the State's biofuels goals?

The State of Hawaii's biofuels goals are a combination of energy, agriculture, environmental, and economic objectives, as summarized below:

- ***Energy***: reduce oil dependence, lower costs to consumers, and increase energy security through production of indigenous fuels;
- ***Agriculture***: preserve important agricultural lands, revitalize the rural economy, and avoid tradeoffs between fuel and food/diversified agriculture;
- ***Environment***: protect the environment, foster sustainable agricultural production, and integrate biofuels and their byproducts into the agricultural sector;
- ***Economy***: diversify the economic base and expand economic growth.

In 1994, Act 199 (Session Laws of Hawaii (SLH) 1994) created a ten percent ethanol content requirement for gasoline, which ultimately took effect in April 2006. Act 240 (SLH 2006) created an alternate fuel standard (AFS) for the State, with a goal to provide 10% of highway fuel demand from alternate fuels by 2010; 15% by 2015; and 20% by 2020. Hawaii's Renewable Portfolio Standard (RPS), established by Act 95 (SLH 2004) requires that 20% of net electricity sales come from renewable energy by 2020, and includes biofuels as a renewable energy source. The RPS law also sets milestones of 10% by 2010, and 15% by 2015.

In support of these goals, the State currently provides an investment tax credit for ethanol equal to 30% of nameplate capacity per year for the first 40 million gallons,[1] a reduction in state and local fuels taxes (a weighted average of $0.21/gal ethanol and $0.26/gal biodiesel) and a $0.05/gal State government procurement preference for biodiesel. The Federal EPACT 2005 created three major incentives for biofuels, including most notably a $0.51/gal ethanol blender credit set to expire in 2010, a $1.00/gal agri-biodiesel credit that is set to expire in 2008, and a $0.10/gal production tax credit for small agri-biodiesel or ethanol producers, to expire at the end of 2008 and 2010, respectively.

II. How much biofuel do we need to meet the goals?

Over the next twenty years, highway fuel demand, and thus biofuels demand for vehicles, will depend on both economic growth and fleet efficiency improvements. DBEDT and RMI are currently analyzing the impact of improved vehicle efficiency, which has the potential to reduce absolute oil demand from current levels by 20% or more by 2020.[2] Because this analysis is ongoing, the impact of potential efficiency improvements is not included in Table 1 below, which provides a maximum estimate of projected vehicle highway demand for biofuels:

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[1] Up to a maximum of 100% of the investment.

[2] Rocky Mountain Institute. *Hawaii's $3 Billion Efficiency Prize*. Hawaii Energy Policy Forum, 2003.

Table 1. Estimated maximum highway biofuels demand, based on AFS requirements[3]

Estimated Maximum Highway Ethanol Demand (MMgal)				
	2006 (8.5%)	2010 (10%)	2015 (15%)	2020 (20%)
Oahu	26.2	33.3	51.5	71.8
Hawaii	5.9	8.1	12.9	18.6
Maui/Lanai/Molokai	4.6	6.2	10.0	14.4
Kauai	2.1	2.8	4.5	6.3
State Total	38.8	50.4	78.9	111.0

Estimated Maximum Highway Biodiesel Demand (MMgal)				
	2006 (0%)	2010 (10%)	2015 (15%)	2020 (20%)
Oahu	0	3.0	5.0	7.3
Hawaii	0	1.6	2.9	4.4
Maui/Lanai/Molokai	0	0.6	1.0	1.5
Kauai	0	0.4	0.7	1.0
State Total	0	5.6	9.6	14.2

Beyond highway fuel use, the state's electric utilities and marine vessels refueling in Hawaii consume the majority of the diesel produced in Hawaii (110 and 65 million gallons, respectively).[4] Marine fuel use is not regulated. However, Hawaii's electric utilities are subject to the RPS law. The HEI utilities -- HECO, MECO, and HELCO – can aggregate their efforts to meet the RPS standard. Under the current law, which permits using energy efficiency and renewable energy to meet the standard, they should have no difficulty in doing so. However, should the standard be changed, as is currently within the purview of the Public Utilities Commission, such that the standard had to be met entirely by renewable energy, the use of biofuels could play an important role in allowing the utilities to comply with the law. In this case, HEI could face up to a ~1,000 GWh/year gap, based on current and planned renewable energy projects and an estimated 2.5% per year electric load growth rate.

The magnitude and duration of utility fuel demand makes these companies potential anchors of future biofuels demand. HECO recently issued an RFP for ethanol for its proposed 110 MW project at Campbell Industrial Park, and MECO has already demonstrated the viability of using biodiesel to power startup units. A single 130 MW baseload power plant using biofuels would require as much biofuel as the entire AFS target for highway fuels.[5]

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[3] Gasoline and diesel consumption have been forecast linearly based on historical data, ethanol demand based on the E10 standard (10% of 85% of highway gasoline demand) in 2006, and ethanol and biodiesel demand based on the AFS goals of 10% of highway fuel in 2010, 15% in 2015, and 20% in 2020. If significant efficiency improvements reduced total highway fuel demand, total highway ethanol and biodiesel demand would likewise be reduced. Approximately 700,000 gallons of biodiesel are currently produced in Hawaii, but these are not included in Table 1 because they are not currently required by law.

[4] Utility and marine diesel data provided by DBEDT.

[5] Either 72 million gallons of biodiesel or 111 million gallons of ethanol will produce 1,000 GWh/year.

III. What vehicle changes must occur to realize the 20% AFS target?

In the ground transportation sector, the market for biofuels depends on consumer adoption of flex fuel vehicles (FFVs) that can use a blend of up to 85% ethanol (E85), and the use of biodiesel in diesel vehicles.[6]

Only about 2% of Hawaii's vehicle fleet is E85 FFVs today, but with the current shift in U.S. automaker strategy towards FFVs, this number could increase significantly. To meet the 20% AFS target, about 14% of the vehicle population would need to be FFVs by 2020. Furthermore, oil companies will need to invest millions of dollars to develop E85 infrastructure. For example, each E85 station requires an investment of $40,000 to $100,000 or more, plus costs for ethanol terminals and storage tanks.[7]

Nearly all diesel trucks and buses are warranted to run on 5% biodiesel (B5) today. European and U.S. truck manufacturers are already developing engines that will be warranted to run on 20% biodiesel (B20) within the next five years, and work is ongoing for an ASTM B20 standard.

Diesel use in the power and marine sectors could be converted to 100% biodiesel (B100), assuming the fuel is cost-competitive. Environmental benefits to both these sectors could be important drivers of this shift. Furthermore, the Environmental Protection Agency's Ultra Low Sulfur Diesel (ULSD) rule took effect in June 2006, requiring a reduction in diesel sulfur from 500 ppm to 15 ppm by 2010.[8] While there is uncertainty as to whether Hawaii's refineries will be able to convert to ULSD production, 2% biodiesel blends (B2) provide the lubricity needed once sulfur is removed.

IV. Does Hawaii have enough available land to produce the biofuels required to meet the State's goals?

Yes. The amount of acreage available has been estimated by several recent studies, including the 2003 *Hawaii Ethanol Alternatives* study by Stillwater Associates; the 2003 *Economic Impact Assessment for Ethanol Production and Use in Hawaii* study by BBI International Consulting; and the 1999 *Siting Evaluation for Biomass-Ethanol Production in Hawaii* study by the UH College of Tropical Agriculture and Human Resources.

RMI has estimated additional available acreage based on a combination of Agriculture Land of Importance to the State of Hawaii (ALISH) agricultural designation, soil type, existing agricultural production, and parcel size. RMI has included forestry land because of the potential for cellulosic feedstocks for ethanol production.[9] RMI notes that much of the available acreage

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[6] The 20% AFS target is for the transportation sector as a whole. For illustrative purposes only, gasoline and diesel displacement are calculated separately below.
[7] National Ethanol Vehicle Coalition. 2004.
[8] 40 CFR Parts 69, 80, 86.
[9] To determine the viable acreage potential for Hawaii, GIS maps were created with the following overlays: ALISH agricultural designations, non-urban State Land Use Districts, USDA soil types conducive to biomass production, and parcel sizes greater than 10 acres. Land slope would also affect viability of biofuels production (over 15% slope is generally unviable); however, slope data was not available at the time of printing. See Attachment C for maps of available acreage identified through this analysis.

is not contiguous, and is not likely to meet the minimum efficient scale necessary for economically viable sugarcane production. Ownership of the majority of this land is concentrated among a handful of entities, including State and County Government agencies, Kamehameha Schools, Alexander & Baldwin, Maui Land & Pineapple, and the Campbell Estate.

Table 2. Estimated available acreage for biomass production

ESTIMATED AVAILABLE ACREAGE FOR BIOMASS PRODUCTION (acres)					
	Maui	**Kauai**	**Oahu**	**Hawaii**	**TOTAL**
Stillwater/Kinoshita estimates	26,000	7,000	25,500	27,000	85,500
Land currently used for sugar production	36,700	11,100	0	0	47,800
Sub-total	**62,700**	**18,100**	**25,500**	**27,000**	**133,300**
Additional available prime farmland	0	28,200	11,300	8,000	47,500
Sub-total	**62,700**	**46,300**	**36,800**	**35,000**	**180,800**
Existing non-sugar agricultural production	9,300	3,000	17,300	11,800	41,400
Max potential (exclusive of non-sugar ag land)	**53,400**	**43,300**	**19,500**	**23,200**	**139,400**

Current sugarcane yields range from 10-21 dry tons of unburned cane per acre-year,[10] or 620-1,310 gallons of ethanol/acre, depending on the particular site's soil type, rainfall, and irrigation regime.

Although large-scale oil seed production has not been attempted in Hawaii, estimates of annual oil seed production from row and tree crops suggest potential yields of 2,100-4,400 lbs. oil/acre for tree crops and 300-900 lbs. oil/acre for row crops, which could yield 300-600 gal biodiesel/acre and 50-130 gal biodiesel/acre, respectively.[11] Based on these ranges, the following table provides a high level estimate of the amount of acreage needed to meet Hawaii's future AFS-driven demand, assuming that *all* current sugar production was converted to ethanol, and *all* available waste oil was converted to biodiesel.[12]

[10] Sugarcane yield is reported in dry tons of unburned cane harvested annually. Historically, Hawaii's sugar industry has reported burned cane harvested bi-annually. However, it is likely that harvesting practices for sugarcane grown as an energy crop would be modified.

[11] Hawaii Agricultural Research Center. *Biodiesel Crop Implementation in Hawaii*. July 2006 Draft Report. Tree crops include oil palm (635 gal./acre), kukui (380 gal./acre), and jatropha (300 gal./acre). Row crops include soy beans (48 gal./acre) and rape seed (127 gal./acre).

[12] Potential production from existing sugarcane lands was estimated using total acreage currently in sugar production and conversion yield of ~61 gal./dry ton. Existing and potential waste oil biodiesel was estimated based on existing production as reported by Pacific Biodiesel, and estimates of additional waste oil available extrapolated from: County of Hawaii, Department of Environmental Management. *Study Relating to Used Cooking Oil Generation and Biodiesel Production Incentives in the County of Hawaii*. December 2004.

Table 3. Estimated acreage required to meet future biofuel demand[13]

Ethanol Demand and Acreage Required				
	2006	2010	2015	2020
Ethanol required for AFS (Mmgal)	38.8	50.4	78.9	111
Potential production from existing sugar (Mmgal)	51	51	51	51
Net additional ethanol required (Mmgal)	0	0	28	60
Required land (acres, in addition to existing sugar)	0	0	26,599	57,703

Biodiesel Demand and Acreage Required				
	2006	2010	2015	2020
Biodiesel required for AFS (Mmgal)	0	5.6	9.6	14.2
Existing and potential waste oil production (Mmgal)	2.5	2.5	2.5	2.5
Net additional biodiesel required (Mmgal)	0	3.1	7.1	11.7
Required land (acres, high potential tree crops)	0	6,889	15,778	26,000

Assuming existing sugarcane production is entirely converted into ethanol,[14] an additional 83,000 acres of prime farmland are needed to meet the AFS target for ethanol and biodiesel, which compares favorably to Kinoshita's estimate of 85,500 acres of land suitable for sugarcane production.[15] If existing sugarcane is not entirely converted to ethanol production, or if lower yields are realized, then additional acreage will be necessary, as well as the use of more marginal lands and, potentially, cellulosic ethanol production technologies.

V. Can Hawaii's water resources be reliably accessed in sufficient quantity to support biofuels production?

This answer needs further study. It is not clear whether there are sufficient water resources. While rainfall may be adequate for some biofuels (particularly biodiesel and cellulosic crops) in some areas, irrigation will be required for economically viable sugar cane yields in other areas. Crops used for fuel rather than for food may be able to utilize non-potable water sources.

While there is extensive irrigation infrastructure throughout the islands,[16] much of it has significantly deteriorated following the sugarcane plantation closures in the 1980s and 1990s. The most comprehensive study of the status of these irrigation systems was conducted by the Hawaii Department of Agriculture in 2004, which included ten irrigation systems. Many more irrigation systems are still in operation, although little data is available as to their state of repair. The following table summarizes the estimated costs of rehabilitating and improving the ten systems studied, and indicates that not all of them would be cost effective for sugar cane production.

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[13] Technological shifts that could potentially change (decrease) the acreage required are discussed in section IX.
[14] Existing sugarcane production is 36,700 acres on Maui (HC&S), and 11,100 acres on Kauai (G&R). Source: 2002 National Agricultural Statistical Service.
[15] Kinoshita, Charles. *Siting Evaluation for Biomass-Ethanol Production in Hawaii.* University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources. October 1999.
[16] See Attachment C, which indicates the location and extent of Hawaii's irrigation infrastructure.

Table 4. Estimated costs for rehabilitating select irrigation systems to support sugar-based ethanol production[17]

System	Total Cost	Potential Acres Served	$/Gallon Ethanol Produced
Kokee Ditch	$ 1,712,000	3,519	$ 0.05
Kekaha Ditch	$ 6,790,000	6,566	$ 0.10
Molokai	$ 16,776,000	9,885	$ 0.17
Waiahole Ditch	$ 10,668,000	6,270	$ 0.17
East Kauai	$ 10,387,000	5,922	$ 0.18
Lower Hamakua Ditch	$ 9,586,000	4,765	$ 0.20
ML&P/Pioneer Mill	$ 8,912,000	3,533	$ 0.25
Waimanalo	$ 5,492,000	1,601	$ 0.34
Upcountry Maui	$ 9,274,000	1,751	$ 0.53
Waimea	$ 20,963,000	1,367	$ 1.54

Another important factor is that landowners' and farmers' legal rights to access water are in a state of flux. Due to drought conditions over the past five years and increased demand, Hawaii's water resource has been contested in the courts in a number of cases relating to issues of surface water transfers, stream diversion, minimum stream flow, total maximum daily loads, and native Hawaiian rights, among others. In fact, it is quite likely that any water use dispute will ultimately be decided by the courts, leading to potentially long delays in gaining access to water for a biofuels project. Further uncertainty with regards to water arises due to the lack of a comprehensive agricultural water use and development plan.

VI. Are biofuels competitive with petroleum products on a national scale?

Nationally, both ethanol and biodiesel production costs are highly competitive with gasoline and diesel at current and projected prices. Figure 1 below shows historical ethanol and gasoline prices, as well as estimated corn ethanol production costs on an energy equivalent basis (ethanol has 23% less energy than an equivalent volume of gasoline). Although ethanol prices are higher than gasoline today, this is a temporary effect due to an ethanol shortage and a spike in demand caused by the phase out of MBTE.

Production costs for corn-based ethanol (including a $0.51/gal Federal tax credit), shown in green, result in a production profit margin of $1.50/gal today, narrowing to $0.60/gal based on futures prices. The financial implications are that ethanol investors may be able to recover their capital investment, on a cash basis, within two years, with industry estimates of project IRRs at greater than 50%. Even if Federal tax credits are not extended past 2010 (indicated by the step jump in price of $0.51/gal ethanol), ethanol should still be produced at rough parity with gasoline.

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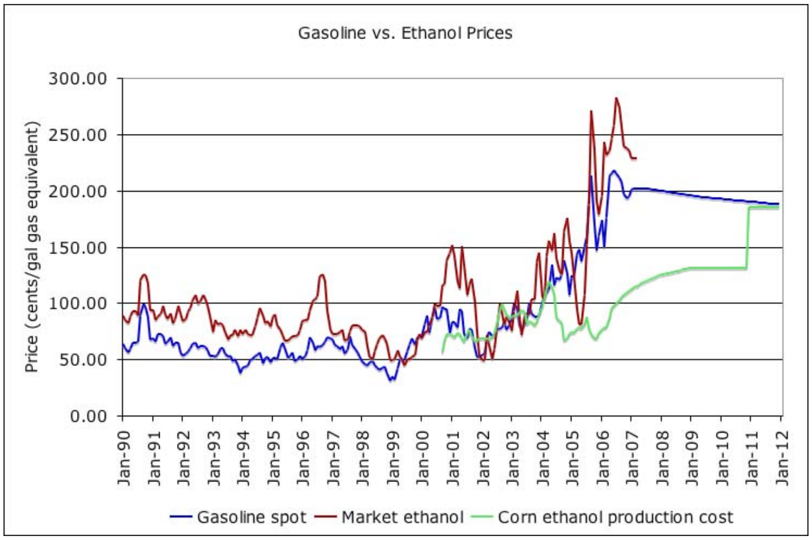
[17] Based on: State of Hawaii Department of Agriculture. *Agricultural Water Use and Development Plan*. December 2003 (Revised December 2004).

Figure 1. Comparison of historical and estimated future national average gasoline prices and ethanol prices and production costs[18]



Biodiesel production can also be very profitable, but the choice of feedstock is particularly important. Figure 2 below compares national average diesel prices to biodiesel costs for production from waste oil, palm oil, and soy from 1990 to 2012. Waste oil biodiesel can be produced for less than $1.50/gal, and the net cost is $1.00 after the $0.50/gal waste oil tax credit. It should remain far below diesel prices even if the tax credit is not extended past its current 2008 expiration date. Biodiesel from imported palm oil costs about $1.00/gal after a $1.00 agri-biodiesel tax credit, and is below parity if the tax credit expires as scheduled in 2008. Soy-based biodiesel can be produced for $1.50/gal after tax credits, but would be at or above parity with diesel in the absence of tax credits.[19] Capital costs for biodiesel plants are approximately $0.15/gal, which may be recovered on a cash basis within 3-4 years, with project IRRs in the 30% range.

Given the overwhelming positive economics, it should be no surprise that biodiesel production has attracted millions of dollars in private investment over the last several years.

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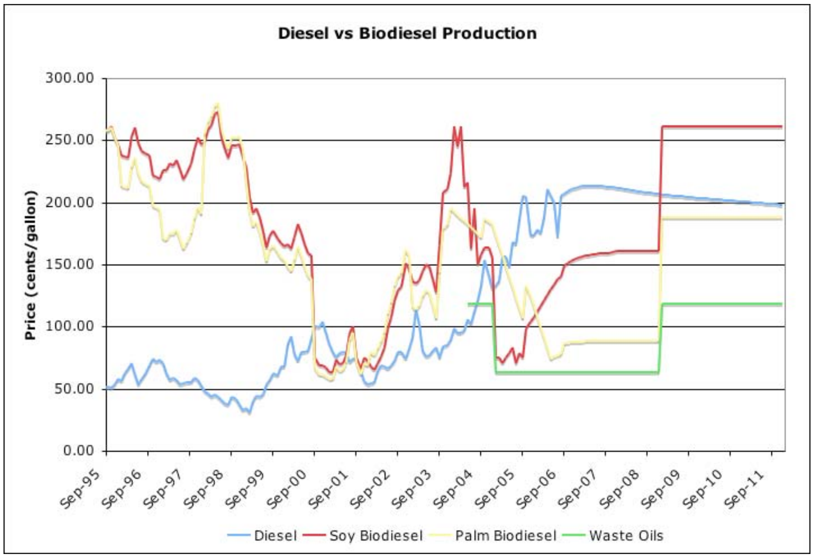
[18] Gasoline and market ethanol (represented in blue and red) are reported as selling prices. Corn ethanol (represented in green) represents the estimated production cost.

[19] Expiration of current biodiesel production tax credits are indicated on Figure 2 by step jumps in prices in 2008. However, it is reasonable to think that the tax credits will be extended beyond their current expiration.

Figure 2. Comparison of historical and estimated future national average diesel and biodiesel prices and biodiesel production costs



VII. Can biofuels production in Hawaii be profitable?

Biofuels feedstocks (corn, sugar, soy, and palm) are globally traded market commodities. Locally grown biofuels will only be economic in the long run if they can be produced at or below import parity price for both the feedstock and the finished fuel.

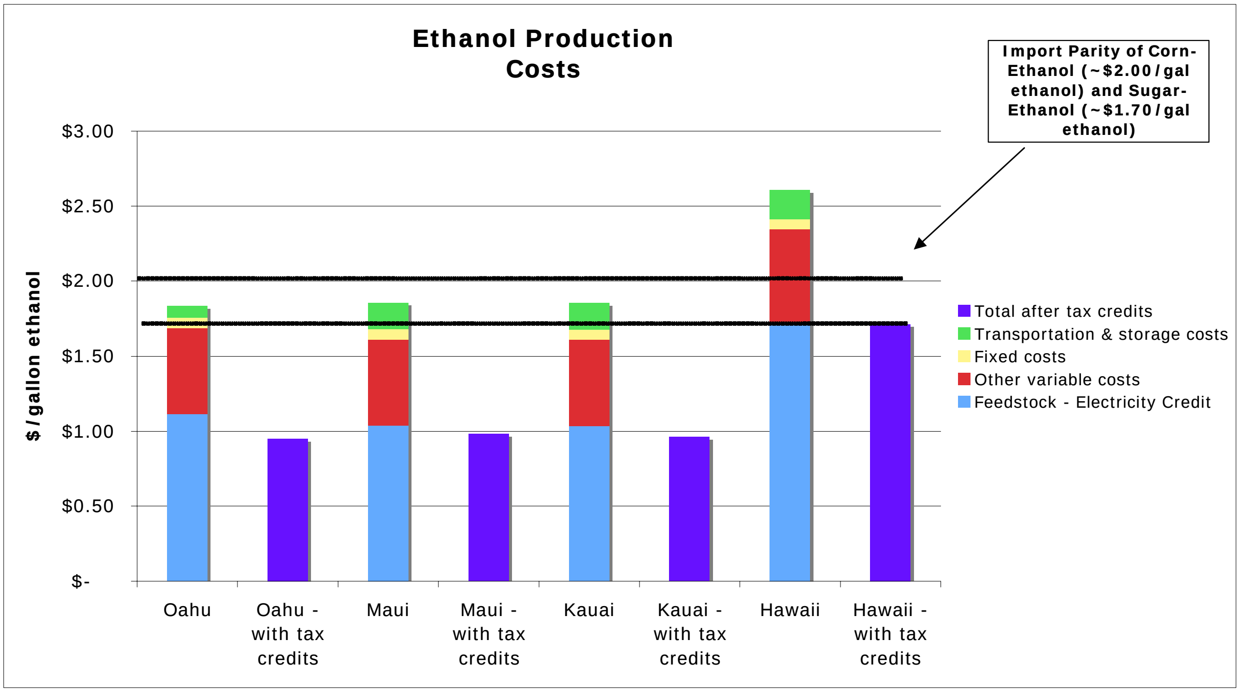
Ethanol

RMI estimates the long run import parity price for ethanol before blender and fuel tax credits at at ~$2.00/gal ethanol for U.S. corn-based ethanol and ~$1.70/gal ethanol for Brazilian sugar-based ethanol, including tariffs.[20] Recent studies of production economics, assuming an integrated system with cogeneration of process heat and power from bagasse and the sale of excess power, suggest the following ethanol costs, assuming a baseline agricultural land rent to the landowner of $200 per acre/year.[21] Hawaii production costs, including the 30% investment tax credit for the first 40 million gallons, are shown in the multi-colored bars in Figure 3 below, and fall within the pre-tax credit import parity range. The purple bars indicate Hawaii production costs after all tax credits (imported ethanol would also receive the blender and fuel tax credits).

[20] Corn-based ethanol import parity was calculated using the 2007 futures corn price, average conversion costs, and $0.22/gal transport and storage cost. Sugar-based ethanol import parity was calculated with OECD estimates of Brazilian production costs, $0.54/gal + 2.5% tariff and $0.29/gal transport and storage cost.

[21] RMI estimate.

Figure 3. Estimated Hawaii Ethanol Production Costs



Significantly lower estimated yields on the Island of Hawaii lead to an expected production cost above import parity. Higher yields on Oahu, Maui, and Kauai result in lower production costs, due in part to a lower cost of irrigation water than on the Island of Hawaii.

Biodiesel

The import parity price for Malaysian palm oil biodiesel is estimated at $1.14/gal, assuming $0.18/lb for feedstock and $0.19/gal for transportation and storage.[22] In the absence of tariff increases, imported palm oil is cheaper than imported U.S. soy oil at $1.67/gal biodiesel, assuming $0.27/lb soybean oil cost, plus $0.22/gal for transportation and storage.[23] Therefore, the key question is whether Hawaii can compete with subsidized low labor cost Asian production.

Hawaii's only commercial experience with biodiesel is production from waste oil as a feedstock by Pacific Biodiesel on Oahu and Maui. Currently, Pacific Biodiesel produces about 700,000 gallons a year. RMI estimates that there is potentially enough waste cooking oil in Hawaii to produce 2-2.5 million gallons of biodiesel per year, with a cost largely depending on backhaul transportation.[24] Dedicated crop cost estimates for Hawaii are not available.[25] Further study into the viability of oil crops in Hawaii must be conducted.

[22] Feedstock price based on 2007 futures price of palm oil. Transportation and storage costs based on Stillwater Associates.
[23] Feedstock price based on 2007 futures price of soy oil. Transport cost from Stillwater Associates. *Hawaii Ethanol Alternatives*. August 2003.
[24] Based in part on: Turn, Scott. *Biomass and Bioenergy Resource Assessment.* State of Hawaii, Hawaii Natural Energy Institute. December 2002, as well as Solid Waste Division, County of Hawaii. *Study Relating to Used*

VIII. How might the overall Hawaii economy benefit from biofuels?

The biofuels sector will provide significant economic benefits by helping reduce the state's import dependence on both energy and animal feed, as well as improving energy security. These are summarized below.

Synergies in Power & Waste Recovery

Each 10 million gallon ethanol facility can potentially produce enough excess electricity to sell about 2-2.5 MW (an estimated 14,610 to 17,520 MWh based upon an 80% capacity factor) of renewable biomass power to the grid.[26] Therefore, the net oil (and carbon) reduction for ethanol facilities is a combination of both the oil displaced by the ethanol fuel produced and utility fuel oil displaced by electricity cogenerated by the ethanol production facilities and sold to the utilities.

The use of municipal solid waste (MSW) and waste oils for biomass power and biofuels reduces both the solid waste disposal and energy challenges that are faced on all islands, particularly Hawaii and Kauai.

Synergies in Agriculture

If the biodiesel industry is based on locally grown crops, the economic benefits multiply. Many jobs would be created to grow, harvest, transport, and process the crops. The byproducts from the crushing process for most oil seeds include glycerin and a high protein animal feed. Use of this byproduct would both displace the existing, currently imported feed, and, more importantly, enable the expansion of the local livestock sector. Livestock manure can be used for biogas, and the residuals from biogas create high quality, low cost organic fertilizer.

Although imported vegetable oil feedstocks do not provide these benefits, use of imports will undoubtedly be required as a bridge strategy until agricultural research on cultivar selection is completed.

Synergies in Security

Biodiesel manufacturing is modular; hence, the scale can range from distributed co-op based operations up to large-scale centralized facilities. The additional ethanol terminal capacity and production capability would allow the state to extend its fuel reserves in the event of a natural or man-made disaster that temporarily curtails petroleum supply. Use of both these fuels will enhance energy security.

Cooking Oil Generation and Biodiesel Production Incentives in the County of Hawaii. December 2004, and 2002 U.S. Census Economic Census: Accommodation and Foodservices: Hawaii.

[25] Biodiesel can also be produced from animal renderings, and should be included in any analysis of biodiesel potential. In general, animal renderings can be expected to yield ~60 gallons biodiesel per ton of renderings. "Anything into Oil", Brad Lemley, *Discover* Magazine, Vol. 24 No. 5. May 2003 http://lists.envirolink.org/pipermail/ar-news/Week-of-Mon-20030804/004435.html

[26] Assuming power is produced at a rate of ~300 kWh/ton of bagasse, and consumed at a rate of ~150 kWh/ton.

The state's utilities and marine operators are the key players in helping the biodiesel industry move forward since they are uniquely positioned to engage in the large scale, long term contracts that are needed to provide the investment certainty for the agricultural and conversion sectors.

IX. Are there technological shifts on the horizon that would change the outlook?

There are three technological shifts that could potentially change the biofuels outlook: (1) improved agronomic and conversion approaches for sugarcane ethanol, (2) cellulosic ethanol, and (3) improved biofuels chemistry.

Improved sugarcane approaches

In recent years, significant research on sugarcane production and conversion has taken place in both the U.S. and Brazil. Full utilization of cane trash, improved higher fiber sugarcane cultivars, and better distillation techniques, could, when combined, significantly improve the net yield of ethanol per acre. The implications are that significantly less land and water may be needed to produce biofuels, and the lower production costs should allow the industry to weather cyclical fuel market conditions.

Cellulosic ethanol

While the conventional sugarcane-based ethanol production process will dominate Hawaii's ethanol production in the short term, technologies to convert cellulose-based crops such as banagrass and eucalyptus, or even the entire sugarcane plant, to ethanol should achieve commercial scale in five to ten years. In addition to diversifying feedstock choices, these crops can sometimes be grown on more marginal land or with less energy and cost input, thereby increasing potential production and reducing costs involved.

Previous Hawaii-specific research into cellulosic crops indicates expected yields of 18 to 28 tons/acre-year,[27] depending on site specifications such as insolation, water availability, and irrigation regime. These higher yields lead to generally lower production costs, estimated by RMI with the enzymatic hydrolysis conversion process at $1.15-1.20/gal ethanol, in the long-run.[28]

There are currently three possible conversion pathways for cellulosic ethanol. The first, ethanol production from municipal solid waste (MSW) using a strong acid hydrolysis process, has just reached commercial scale, and BlueFire Ethanol plans to build its first U.S.-based plant this year. The second process, enzymatic hydrolysis, is being promoted by Iogen Corporation, which plans to begin construction of the first commercial-scale plant in 2007, with full production in 2010.

[27] Low estimate from Kinoshita 1999 for unirrigated banagrass, high estimate from HARC, *Demonstration of Grass Biomass Production on Molokai.* 1996, irrigated average.
[28] Based on: National Renewable Energy Laboratory. A. Aden et al. *Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis for Corn Stover*. June 2002. NREL/TP-510-32438.

Thermal gasification, the third process, is perhaps the most flexible, as it results in a syngas that can be converted into not only biofuels, but also a number of other commodities.

Improved Biofuels Chemistry

European oil companies, notably BP (in partnership with Dupont) and Neste, are actively researching improved production and chemistry approaches to biofuels. These may lead to a fundamentally different set of biofuels molecules that are used to set industry standards. BP and Dupont are backing butanol as a superior substitute for ethanol, because it has greater energy density and avoids the need for a separate liquid fuels infrastructure. Neste and BP believe that hydrotreating vegetable oil produces a superior biodiesel molecule compared to transesterification. Both approaches will require testing by the vehicle OEMs and standardization, and will therefore take several years before they fully enter the market.

X. What systemic barriers have prevented the expansion of Hawaii's biofuels industry?

In our experience, the creation of a biofuels industry faces the same challenges as the creation of a new industrial cluster: actions and investment by agricultural producers, fuel distributors, and vehicle manufacturers must all be synchronized so that supply and distribution capabilities are in place to meet demand. The development of new industrial clusters entails risks across the spread of market participants, some of which can be offset by government actions.

Several persistent barriers have prevented Hawaii's biofuels industry from initiating ethanol production or increasing biodiesel production. These barriers are well known to market participants, and we have categorized them according to where they fall in the biofuels value chain, as shown in Attachment A.

The most critical barriers in the agricultural sector appear to be availability of water rights and supply, along with the attendant need to invest in rehabilitating irrigation systems and the pressures of the real estate market prices toward shifting land from larger scale agricultural uses into more profitable dispositions. Since Hawaii-produced fuels may not be export competitive, there is considerable investment risk in Hawaii-based biofuels production compared to the use of imported product or feedstocks.

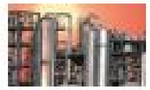
The entire sector faces uncertainty due to the short duration of Federal tax credits, and uncertainty regarding the persistence of government policy towards biofuels. There is need for both buyers and sellers to coordinate on supply, conversion and infrastructure, each of which has long independent lead times. Large "anchor tenant" credit-worthy buyers and sellers must be available to provide the financial certainty needed to invest capital. Both oil and agricultural commodities are independently volatile and impossible to hedge for meaningful periods of time, thus the economic risks beyond the next five years loom large across the entire industry.

Speed to market is critically important. However, in Hawaii, the time it takes to acquire all the necessary state and local permits could cause participants to miss the market window of opportunity, and prevent the industry from seizing the moment.

XI. Conclusions

Hawaii-grown biofuels represents a multi-million dollar opportunity for import displacement in energy and agriculture that can lead the state to a new level of economic, energy and environmental security. Millions of dollars of private sector funds must be invested in the entire biofuels value chain by agricultural producers, fuel producers, fuel distributors, and end users. The comparatively long payback periods and the need for synchronized timing of investments means that there are substantial risks and barriers associated with this development that can only be addressed through innovative partnerships between Hawaii’s public and private sectors. Imports of feedstock or product are likely to be necessary as a transition strategy, but port and terminal access and cost could be bottlenecks. The purpose of this Biofuels Summit is to explore the elements of these partnerships and the solutions to Hawaii’s biofuels challenge.

Attachment A: Key Barriers to Biofuels Development



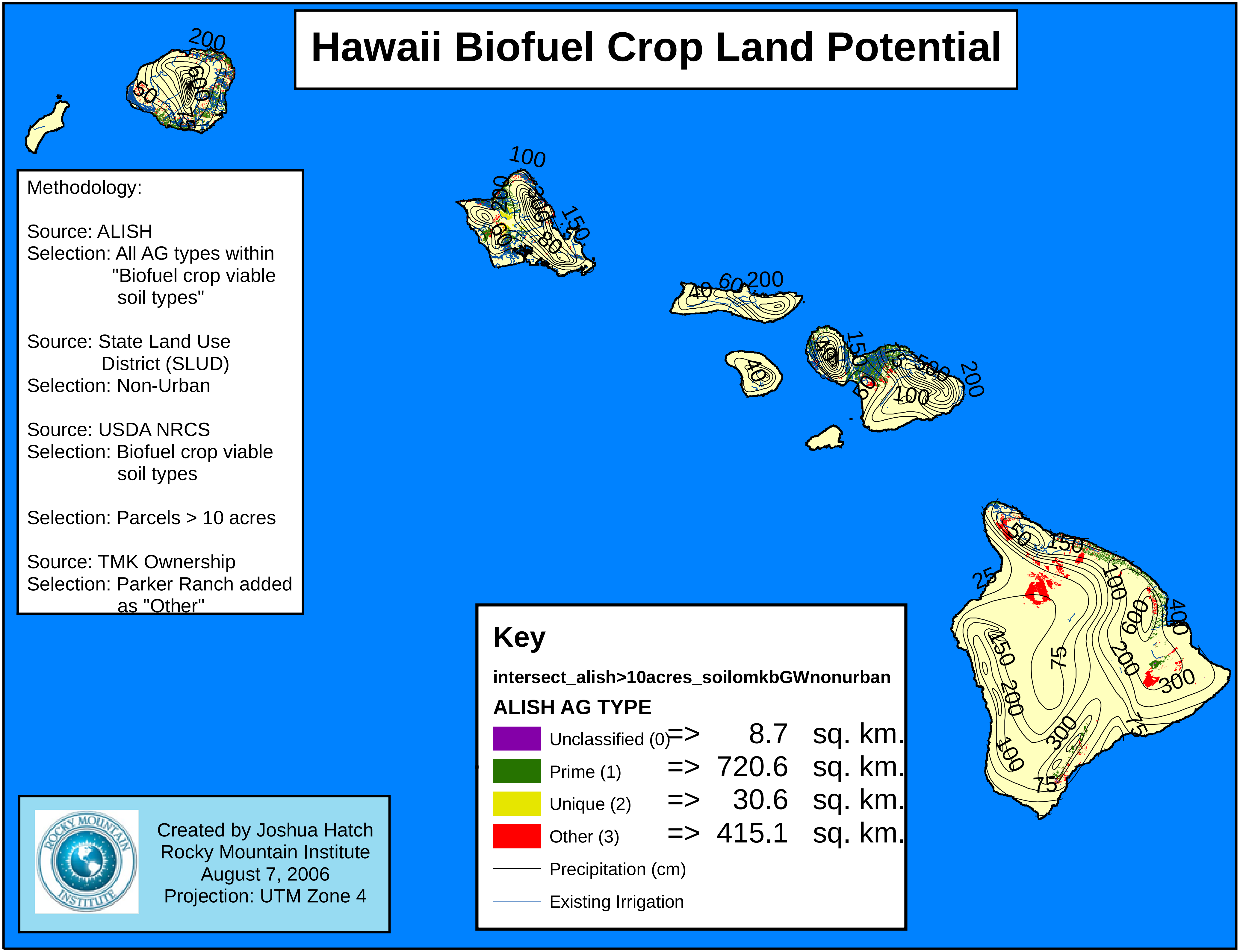
	Agricultural Production	Conversion	Distribution & Storage	End Use
Physical Constraints/ Risks	‣ Land availability (large contiguous tracts) ‣ Road transport capacity ‣ Water availability ‣ Irrigation infrastructure status	‣ Impact to refinery balances	‣ Port capacity ‣ Terminal capacity ‣ Storage tank capacity	‣ Availability and cost of flex fuels vehicles ‣ Terminal/distribution access and cost
Technological Risks	‣ Development/Deployment of higher yield crops ‣ Mechanical harvesting/processing for energy crops	‣ Viability of cellulosic conversion technology	‣ Ethanol/butanol transport capabilities	‣ OEM warranties ‣ Penetration of E85 vehicles
Legal/ Permitting Risks	‣ Water rights ‣ Water permits	‣ Permitting of manufacturing facilities ‣ Siting approvals (county)	‣ Permits for service station retrofits, and terminals	‣ Recovery of long-term fixed price fuel contracts (utility) ‣ OEM warranties ‣ Air emission impacts
Financial-- Price Risks	‣ Labor availability ‣ Real estate market price pressure ‣ Production - imported feedstock spread vs. fixed cost ‣ Water cost	‣ Feedstock – product spreads vs. fixed costs ‣ Duration of federal tax credits ‣ By product market size and pricing	‣ Product spreads vs. fixed cost ‣ Duration of federal tax credits	‣ Biofuel cost vs. petroleum fuel ‣ Duration of federal tax credits
Financial-- Contract Risks	‣ Lead time for feedstock production vs. market demand (security of demand) ‣ Climate change/seasonality vs. demand	‣ Tenure of off-take contract vs. debt ‣ Security of feedstock supply / availability / liquidity ‣ Credit worthy off-takers	‣ Investment recovery of biofuels infrastructure (terminals/stations) ‣ Credit worthy suppliers	‣ Credit-worthy suppliers

Attachment B: Regulatory Issues

Regulatory Issues	Land Use/Siting	Environmental Permitting	Environmental Review
Biodiesel – Processing Using Imported Feedstock (e.g., palm oil, other)	• Within AG or Rural District – State or County SUP, County CUP, County SMA & zoning may be required. • Within Conservation District – BLNR CDUP is required. • Legal? – is the use of imported feedstock at a pre-existing AG mill site a permissible use? • Information from DOT harbors re. capacity to handle bulk cargo, cost & logistics is needed.	• Processing will likely require Air, NPDES & Wastewater permits. • Processing biodiesel byproducts will generate Solid Waste/UIC issues & permits • DOA/legal opinion necessary whether tilling byproduct into soil is feasible. • County landfills have to opine as to their ability to take sludge.	• Legal? – Does activity qualify as an oil refinery or power generating facility which triggers 343 HRS review? • Will general plans have to be reviewed and amended if change proposed to accommodate industrial facilities as a matter of zoning?
Biodiesel – Receipt, Storage, & Processing Using Local Recycled Feedstock	• Within AG or Rural District – State or County SUP, County CUP, County SMA & zoning may be required for an industrial activity which is currently not listed as permissible.	• Solid Waste Facility Permit may be required to receive & store recycled feedstock. • Depending on the processing technology, Air, NPDES, UIC & Wastewater permits may be required.	Same as above.
Biofuel – Cultivation of Local Ethanol Feedstock	Cultivation activities are permissible in the AG District. Potential as Important Agricultural Lands (IAL) crop need to be identified.	CWRM – Availability of surface water for irrigation/Well Permits need to be determined. Improvements to State (DOA) or private water system may be required. Additional permits may be required.	Not applicable.
Biofuel – Processing Ethanol Using Imported Feedstock	Same as for Biodiesel processing using imported feedstock.	Same as for Biodiesel processing using imported feedstock.	Same as for Biodiesel processing using imported feedstock.
Biofuel – Processing Ethanol Using Locally Produced Feedstock	Same as above.	Same as above.	Same as above.

Source: Anthony Ching, State Land Use Commission.

Hawaii Biofuel Crop Land Potential



Methodology:

Source: ALISH
Selection: All AG types within "Biofuel crop viable soil types"

Source: State Land Use District (SLUD)
Selection: Non-Urban

Source: USDA NRCS
Selection: Biofuel crop viable soil types

Selection: Parcels > 10 acres

Source: TMK Ownership
Selection: Parker Ranch added as "Other"

Key

intersect_alish>10acres_soilomkbGWnonurban

ALISH AG TYPE

Unclassified (0)	=>	8.7	sq. km.
Prime (1)	=>	720.6	sq. km.
Unique (2)	=>	30.6	sq. km.
Other (3)	=>	415.1	sq. km.

Precipitation (cm)

Existing Irrigation

Created by Joshua Hatch
Rocky Mountain Institute

August 7, 2006
Projection: UTM Zone 4

Big Island Biofuel Crop Land Potential

Methodology:

Source: ALISH
Selection: All AG types within "Biofuel crop viable soil types"

Source: State Land Use District (SLUD)
Selection: Non-Urban

Source: USDA NRCS
Selection: Biofuel crop viable soil types

Selection: Parcels > 10 acres

Source: TMK Ownership
Selection: Added Parker Ranch as "Other"

Key

intersect_alish>10acres_soilomkbGWnonurban

ALISH AG TYPE

Unclassified (0)	=>	2.1 sq. km.
Prime (1)	=>	141.7 sq. km.
Unique (2)	=>	0.0 sq. km.
Other (3)	=>	284.3 sq. km.

Precipitation (cm)

Existing Irrigation

Created by Joshua Hatch
Rocky Mountain Institute
August 7, 2006
Projection: UTM Zone 4

Oahu Biofuel Crop Land Potential

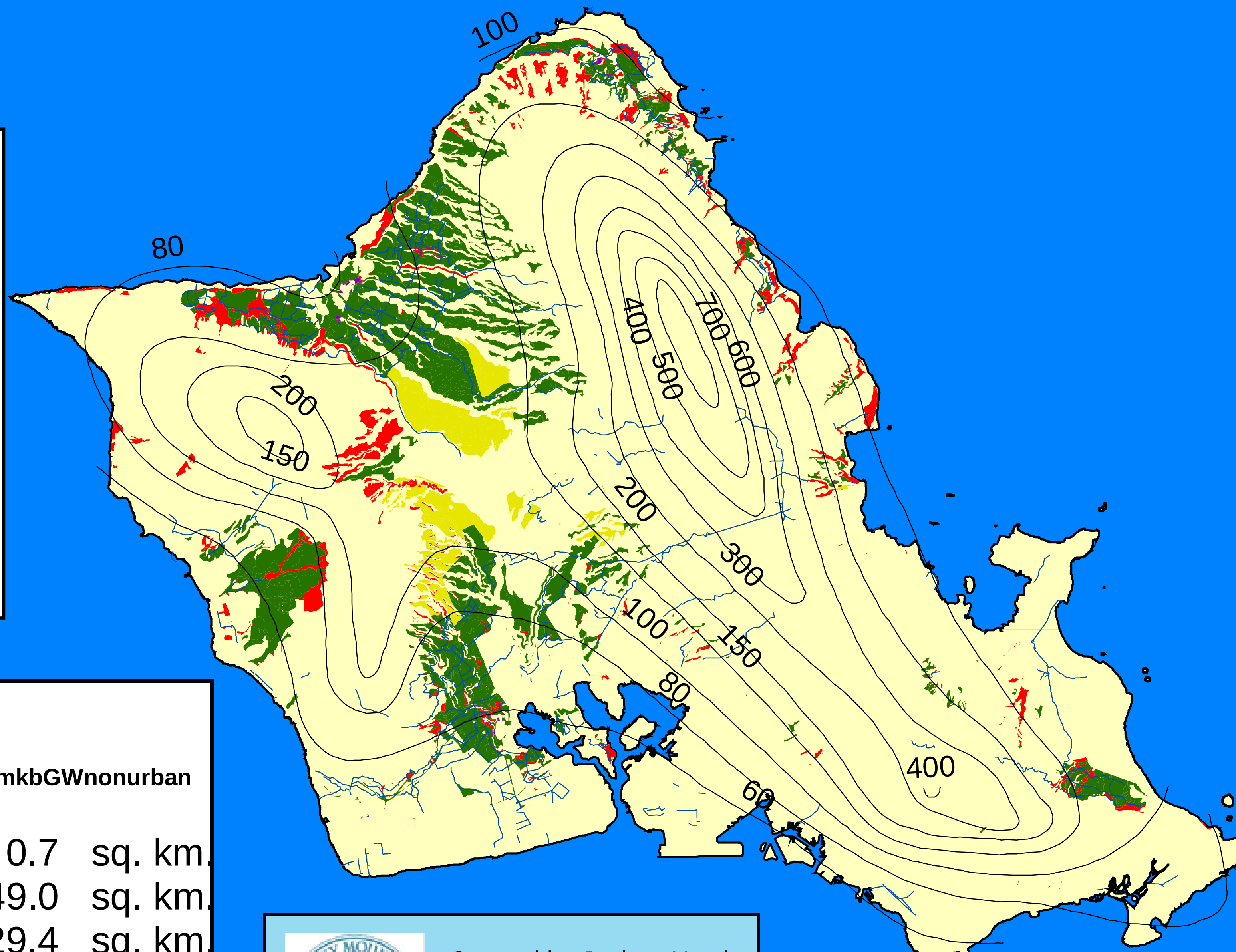
Methodology:

Source: ALISH
Selection: All AG types within "Biofuel crop viable soil types"

Source: State Land Use District (SLUD)
Selection: Non-Urban

Source: USDA NRCS
Selection: Biofuel crop viable soil types

Selection: Parcels > 10 acres



Key

intersect_alish>10acres_soilomkbGWnonurban

ALISH AG TYPE

Unclassified (0)	=>	0.7	sq. km.
Prime (1)	=>	149.0	sq. km.
Unique (2)	=>	29.4	sq. km.
Other (3)	=>	37.3	sq. km.

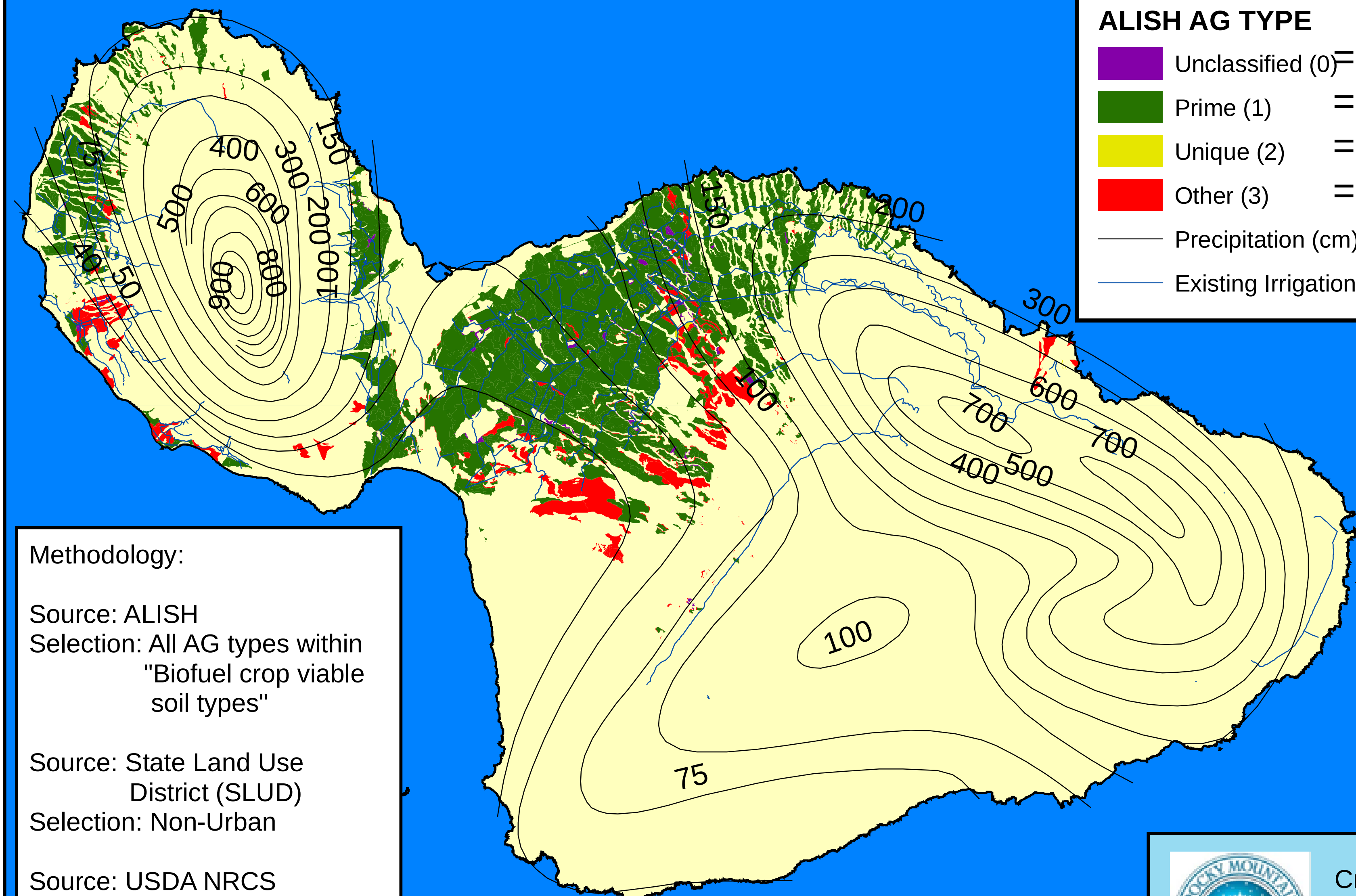
Precipitation (cm)

Existing Irrigation

Created by Joshua Hatch
Rocky Mountain Institute

August 7, 2006
Projection: UTM Zone 4

Maui Biofuel Crop Land Potential



Key

intersect_alish>10acres_soilomkbGWnonurban

ALISH AG TYPE

Unclassified (0)	=> 2.9	sq. km.
Prime (1)	=> 242.4	sq. km.
Unique (2)	=> 0.3	sq. km.
Other (3)	=> 35.4	sq. km.

Precipitation (cm)

Existing Irrigation

Methodology:

Source: ALISH
Selection: All AG types within "Biofuel crop viable soil types"

Source: State Land Use District (SLUD)
Selection: Non-Urban

Source: USDA NRCS
Selection: Biofuel crop viable soil types

Selection: Parcels > 10 acres

Created by Joshua Hatch
Rocky Mountain Institute
August 7, 2006
Projection: UTM Zone 4

Kauai Biofuel Crop Land Potential

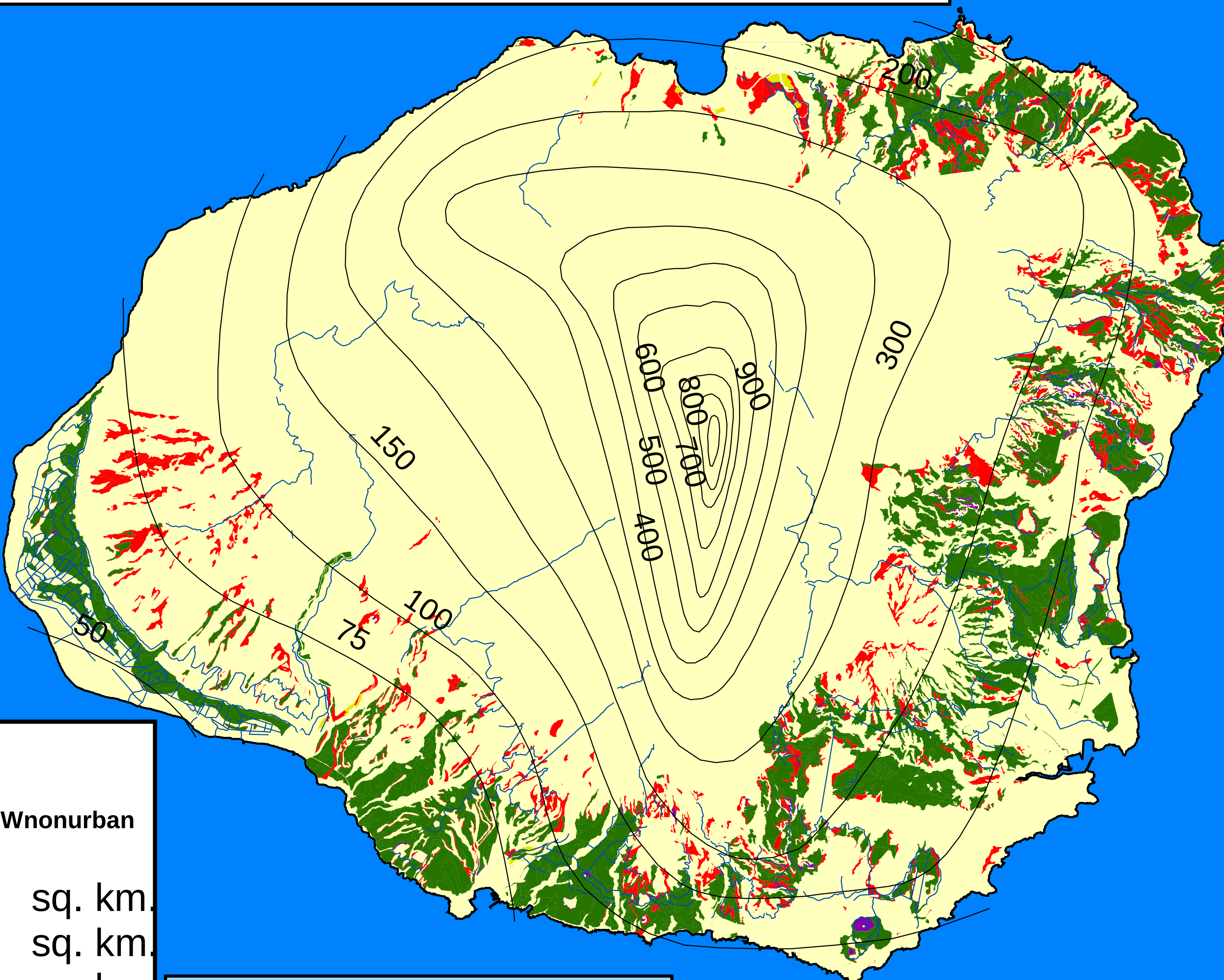
Methodology:

Source: ALISH
Selection: All AG types within "Biofuel crop viable soil types"

Source: State Land Use District (SLUD)
Selection: Non-Urban

Source: USDA NRCS
Selection: Biofuel crop viable soil types

Selection: Parcels > 10 acres



Key

intersect_alish>10acres_soilomkbGWnonurban

ALISH AG TYPE

- Unclassified (0) => 3.0 sq. km.
- Prime (1) => 187.4 sq. km.
- Unique (2) => 1.0 sq. km.
- Other (3) => 58.1 sq. km.
- Precipitation (cm)
- Existing Irrigation

Created by Joshua Hatch
Rocky Mountain Institute
August 7, 2006
Projection: UTM Zone 4