DOE Bioenergy Technologies Office (BETO)
2015 Project Peer Review

High-Yield Feedstock and Biomass Conversion Technology for Renewable Energy and Economic Development

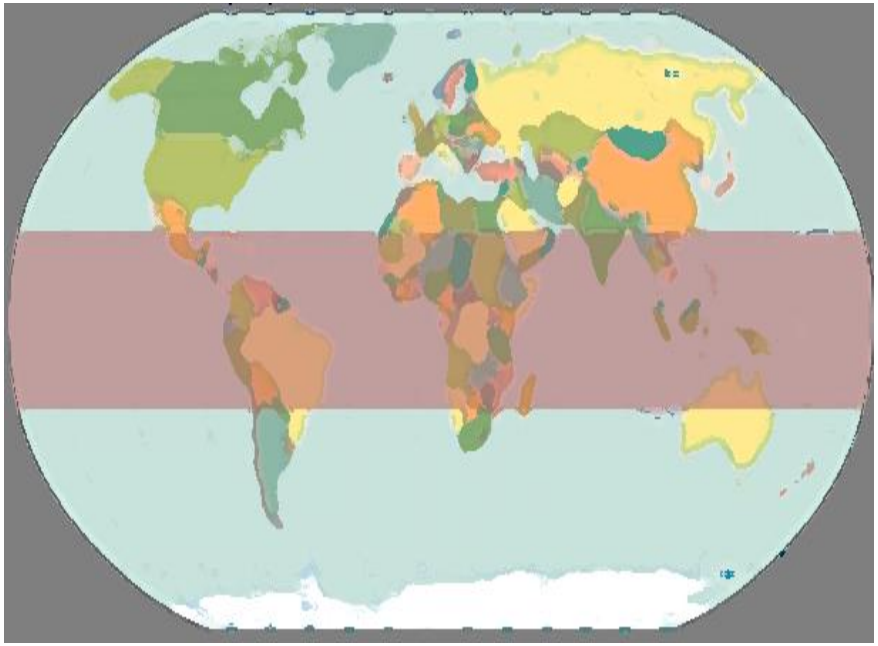
Andrew Hashimoto
University of Hawaii

This presentation does not contain any proprietary, confidential, or otherwise restricted information

GOALS

Develop sustainable, renewable energy systems for Hawaii and the tropics through:

- Biomass feedstocks that grow year-round.
- Feedstock characteristics that impact conversion processes.
- Renewable energy projects that reduce dependence on fossil fuels.
- Impact of renewable energy projects on rural communities.



This project addresses the BETO goal to "Develop sustainable technologies to proved a secure, reliable, and sustainable biomass feedstock supply for the U.S. bioenergy industry."

QUAD CHART OVERVIEW

Timeline

Start: 7/30/2008

End: 9/30/2014

Project completed

BETO Barriers Addressed

- Feedstocks availability and cost (Ft-A).
- Sustainable feedstock production (Ft-B).
- Feedstock quality and monitoring (Ft-E).

Partners

Hamakua Springs Water (HSW)

Hawaiian Commercial & Sugar (HC&S)

	Total Cost FY08-FY12	Total Cost FY2013	Total Cost FY2014	Total Funding
DOE Funded	$5,733,147	$1,577,918	$607,200	$7,918,265
Cost Share U. Hawaii	$337,367	$82,258	$288,851	$708,476
Cost Share HC&S	$505,427	$123,236	$432,734	$1,061,397
Cost Share HSW	$402,101	$98,042	$384,093	$884,236

PROJECT OVERVIEW

HISTORY:

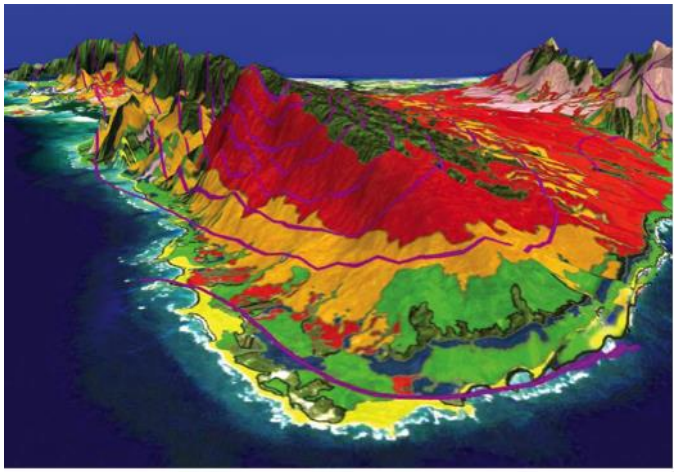
- Started in 2008 as a Congressionally Directed project to assist the Hawaii Clean Energy Initiative.

CONTEXT:

- Strategic location re: "Asia-Pacific Pivot"
- >90% of Hawaii's energy needs depend upon imported fossil fuels.
- Ideal platform for renewable energy projects.

OBJECTIVES:

- Develop high (net) yield of tropical feedstocks
- Optimize biomass conversion of feedstocks
- Develop and assess integrated, sustainable renewable and bioenergy systems for Hawaii and the tropics

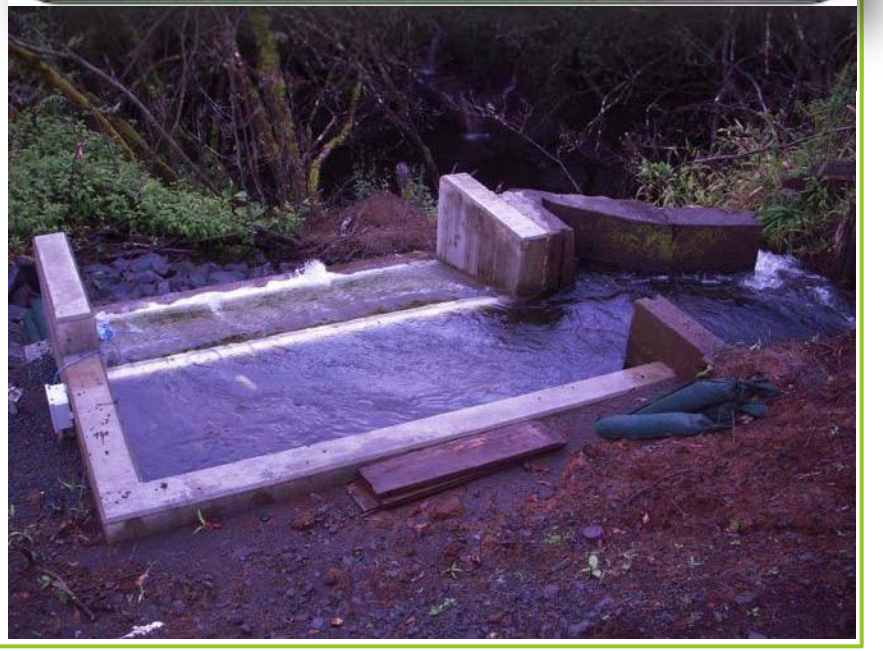


Source: Deenik

APPROACH

- Feedstocks for biofuels:
  - Develop high yield tropical feedstocks
  - Develop feedstock yield models
  - Feedstock-conversion interactions
  - Economic and Carbon cycle assessments

- Renewable energy options:
  - Micro-hydro impact on community economic development
  - Cane trash for biopower
  - Landfill gas utilization
  - Wood chips for coal
  - Solar powered irrigation

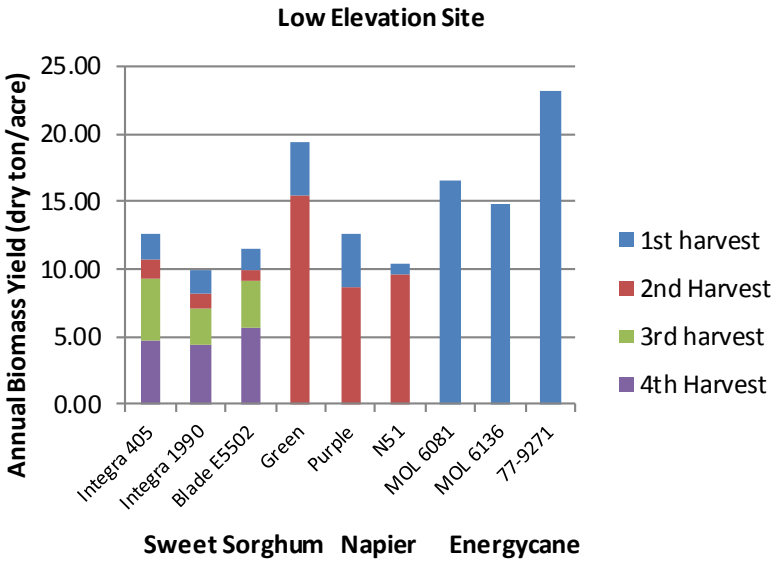


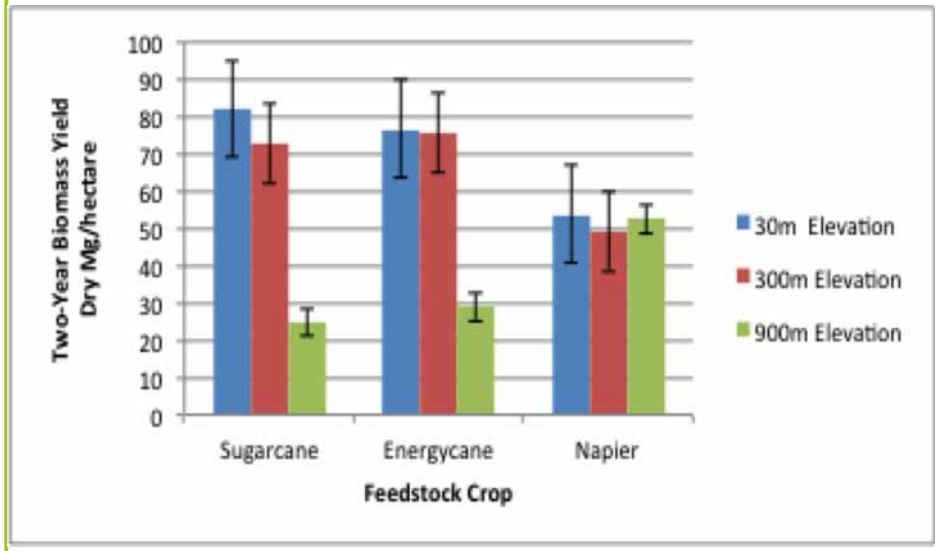
ACCOMPLISHMENTS

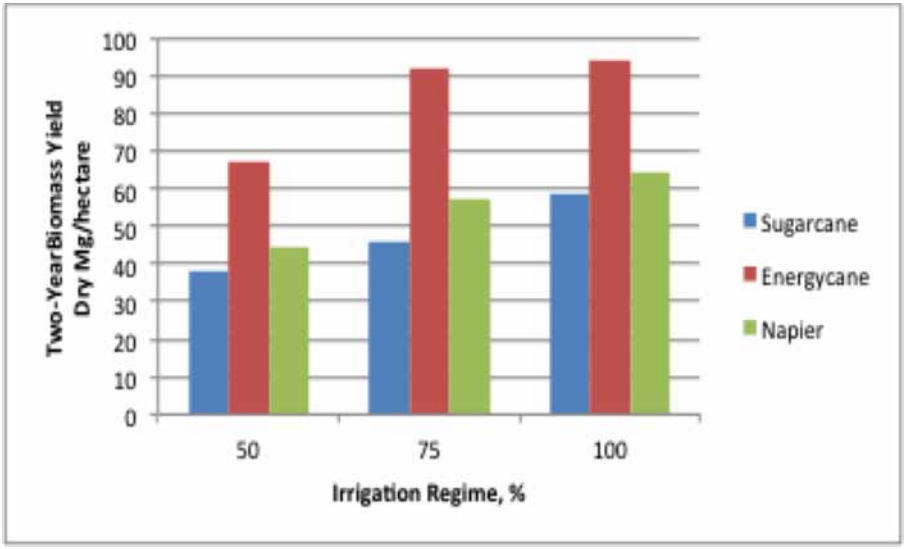
- Native Napier grass accessions collected and evaluated.
- Simple sequence repeat markers for Napier grass identified.
- Napier grass-by-pearl millet hybrids developed and being evaluated.
- Determined chemical composition of target crops, especially compounds/elements that may affect the biochemical or thermochemical conversion of these feedstocks.

ACCOMPLISHMENTS

- Strong genotype-environmental interactions.
- Water affects some crops more that others.
- Harvesting frequency is an economic consideration.







ACCOMPLISHMENTS

· Sugarcane

· Energycane

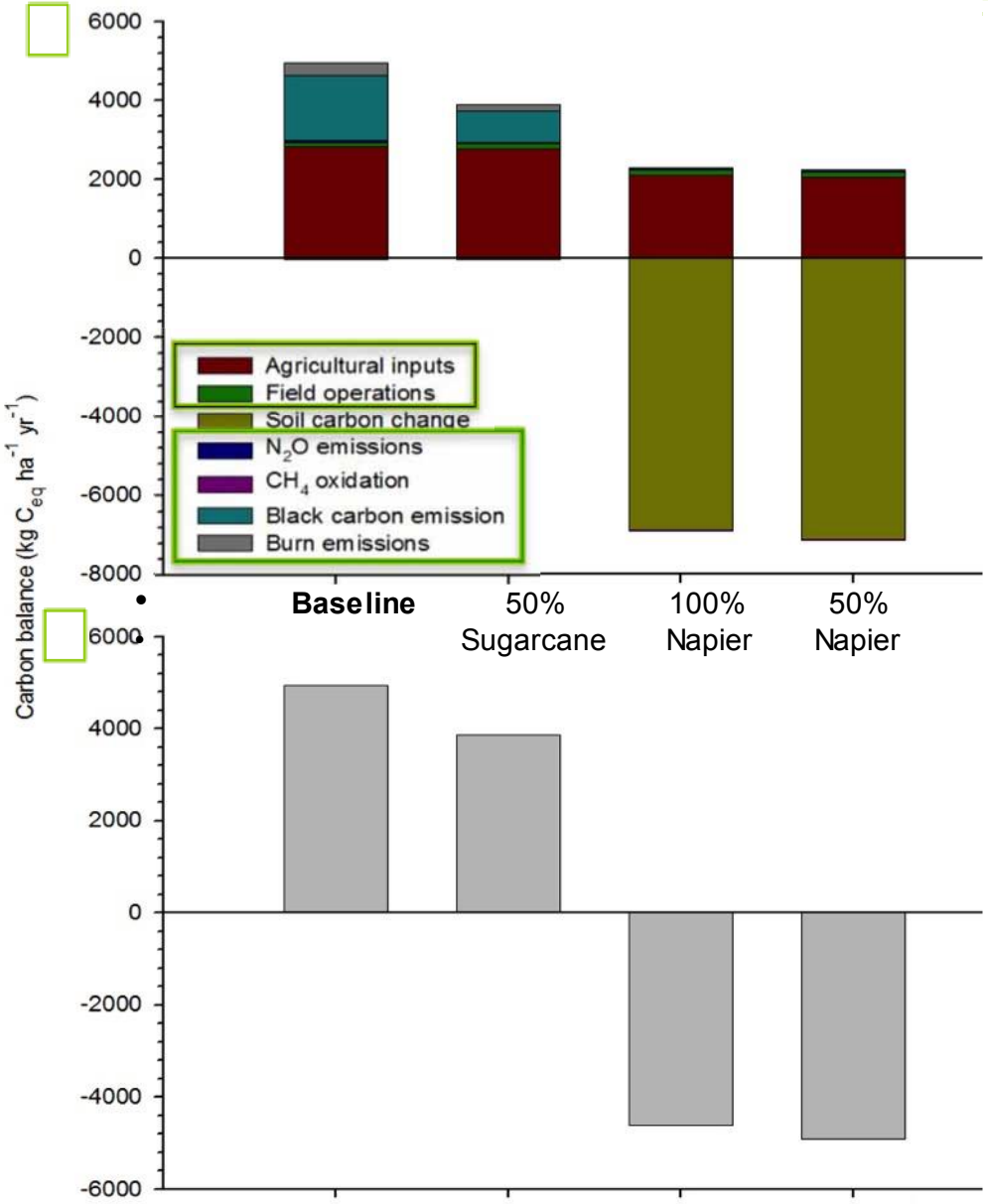
· Root Decay Bags

· *In situ* Root Decomposition

Tracking Root Biomass into Soil Carbon Stock

- Determined decay rates of root tissue for energy- and sugarcane
- Will determine the chemical trajectory of decay using CuO method
- Will trace the root tissue residue into soil C pools using CuO-derived biomarkers

ACCOMPLISHMENTS



- **Fossil-based Emissions (FBE)**
  - Agricultural based inputs were the largest contributor to C emissions overall (60-66% FBE resulting from seed production)
  - Fertilizer-based losses were 11- 12% of FBE
  - Irrigation emissions were low (~1%)

- **Non Fossil-based Emissions (NFBE)**
  - Driven by reduction in biomass yield
  - Pre-harvest burn operations resulted in average ↑ of 1940 kg C_{eq} $ha^{-1}yr^{-1}$
  - N_2O emissions were the largest NFBE

- Soil C accumulation only occurs in ratoon-harvested systems

- Meghan Pawlowski and Norman Meki

ACCOMPLISHMENTS

- Green processing of feedstock:
  - Minimum feedstock storage requirement.
  - Potential co-products from extracted liquid.
  - Must address higher moisture and nutrients in young plants.
- Napiergrass harvested at 2, 4, 6, 8 months.
- Liquid fraction:
  - Younger plants produced larger volumes.
  - High protein fungal biomass grown on extracted liquid.
  - Not economically viable.
- Solid fraction:
  - Dilute acid pretreatment:
    - 95% xylose released.
    - 85% glucose released.
  - Washed solids:
    - Dried.
    - Gassified.

ACCOMPLISHMENTS

Product Gas Composition and Yield

	H_2 %	CO %	CH_4 %	CO_2 %	YIELD L/kg DM
Average	42	24	11	21	884
Range	39-44	22-27	10-12	19-23	814-971

GAS	RANGE
H_2S	100-227 ppmv
COS	1-6 ppmv
C_4H_4S	7-11 ppmv
NH_3	1,700-2,676 ppmv
CN	116-353 mg/m^3
Cl^{-1}	108-224 mg/m^3

ACCOMPLISHMENTS

- Hamakua Springs Water LLC
  - Fruit and vegetable farm, 540 acres, 6.5 MGD stream.
  - 75 KW (112 KW rated) hydro-electric system.
  - Project start delayed because of environmental and utility connectivity issues.
  - Reduced electricity usage from 30,000 to 11,000 KWH/month, savings of $6,000/month.
  - Baseline data for farm economics, and community attitudes and well being.

- Assessed feasibility of sugarcane trash collection and processing.
- Assessed feasibility of landfill gas utilization.
- Assessed feasibility of converting bagasse into biogas.
- Assessed feasibility of 3 MW PV for irrigation with 7 year pay back.

RELEVANCE

Relevance to Biomass Program Multi-Year Program Plan:

- Develop feedstocks, sustainable agronomic practices, and feedstocks production processes and systems (Ft-A, B and E).
- Develop, test and demonstrate sustainable feedstocks logistics systems (Ft-B).

Applications of Expected Project Outputs:

- Results applicable to a vertically integrated, contiguous 38,000 acre agribusiness.
- Results applicable to regional allies in the Asia-Pacific region.
  - Australia (biofuels)
  - Philippines (biopower)
- Department of the Navy's Great Green Fleet Initiative

FUTURE WORK

Continue Research via ONR & BRDI

- Continue multi-year energy crop trials
- Complete feedstock characterization for biochemical and thermochemical conversion to biofuel
- Assess terrestrial carbon stock and dynamics
- Net energy productivity of tropical bioenergy crops
- Validated crop simulation models
- Techno-economic and life cycle assessments.
- Commercial-scale production of tropical energy crop.

SUMMARY

- Strategic importance for the Nation and the tropics.
- Developing high-yield biomass feedstocks that are grown sustainably.
- Strong collaborative team involving academe, government, and large and small commercial entities.
- Information sharing with other state and regional bioenergy entities.
- Information useful for commercial-scale production of energy crops.

ADDITIONAL SLIDES

RESPONSES TO PREVIOUS REVIEW

Long-term involvement of commercial concerns is paramount to success of the project.

The Hawaiian Commercial and Sugar Company (HC&S) has continued to be a collaborator on this project through funding by the Office of Naval Research and the Bioenergy Research and Development Initiative grant. They have been very generous in providing land, labor, expertise and significant cost share contributions. The results from this project was used to submit a response to the DOE FOA-0001179 "Landscape Design for Sustainable Bioenergy Systems." This is a tangible commitment to the ongoing project and the commercialization potential of the results from this project. ZeaChem is a partner on the BRDI project to evaluate the conversion of feedstock to biofuel.

The risk is ending up with many small pieces of important information, but no overall roadmap for future biofuel research and commercialization in Hawaii.

As indicated in the response above, the project has progressed to point of having sufficient information to encourage the HC&S to consider the next step toward commercializing biofuel production in Hawaii. The HC&S has 38,000 acres of contiguous agricultural land in production, and is the largest active agricultural enterprise in Hawaii. The HC&S is viewed as the best opportunity for biofuel production to be commercialized in Hawaii because they have the contiguous land, workforce, equipment and infrastructure.

RESPONSES TO PREVIOUS REVIEW

There is an international need for research on tropical energy crops, especially some of the sustainability impacts that may not get immediate attention in other parts of the tropics.

The focus of this research is on growing biomass feedstocks sustainably and understanding how the feedstock may affect biochemical and thermochemical conversion processes. If the feedstocks can be grown sustainably at competitive costs, viable conversion processes will be evaluated (this is being evaluated in the current BRDI project). This project addresses the fuel versus food issue by developing models to produce feedstocks in areas where food crops are not being grown (this is the reason for the wide ranges in elevation and irrigation for the energy crop evaluations to obtain growth coefficients under this growing conditions). The models developed from the results from this project will estimate the biomass yields, input requirements, economics, life cycle analyses and environmental impacts. As an example of the possible environmental impacts, we will be assessing the impacts of perennial grasses on carbon sequestration in organic-matter depleted soils. Maintaining adequate levels of soils organic carbon in the tropics is always a challenge because of year-round microbial activity in the soil which converts organic carbon into carbon dioxide. If these perennial crops add to the soil carbon balance in tropical soils, this will be a positive factor in the long-term sustainability of growing these crops.

PUBLICATIONS/PRESENTATIONS

Journal Publications:

Takara D., and S.K. Khanal. 2011. Green processing of tropical banagrass into biofuel and biobased products: An innovative biorefinery approach. *Bioresource Technology*. 102 (2): 1587-1592.

Tran, N., P. Illukpitya, J.F. Yanagida, and R. Ogoshi. 2011. "Optimizing biofuel production: An economic analysis for selected biofuel feedstock production in Hawaii", *Journal of Biomass and Bioenergy*, 35: 1756- 1764.

Illukpitiya, P., J. F. Yanagida, R. Ogoshi and G. Uehara. 2013. Sugar-ethanol-electricity co-generation in Hawaii: An application of Linear Programming (L.P.) for optimizing strategies. *Journal of Biomass and Bioenergy* 48: 203-212.

Mochizuki, J., J.F. Yanagida, D. Kumar, D. Takara, and G.S. Murthy. 2014. Life Cycle Assessment of Ethanol Production from Tropical Banagrass (Pennisetum purpureum) Using Green and Dry Processing Technologies in Hawaii. *Journal of Renewable Sustainable Energy*. 6, 043128-1 – 043128-18.

Mochizuki, J., M. Coffman, and J.F. Yanagida. 2015. Market, Welfare, and Land-Use Implications of Lignocellulosic Bioethanol in Hawai`i. *Renewable Energy*, (under review).

Mochizuki, J., J.F. Yanagida, R. Ogoshi, T. Miura, and PS Leung. 2015. GIS Analysis of an Optimal Plant Location – the Case of Banagrass-based Bioethanol Production in Hawai`i. *Biomass and Bioenergy* (under review).

Ma, S., M. Karkee, P. Scharf, and Q. Zhang. 2015. Sugarcane harvester technology: a critical overview. *Applied Engineering in Agriculture*. (under review).

Wells, J., S. Crow, R Ogoshi, B. Torino, A. Hashimoto. 2015. Optimizing Feedstock Selection for Biofuel Production in Hawaii: CuO Oxidative Lignin Products in C4 Grasses. Biomass and Bioenergy. (under review).

Conference Proceedings:

Hashimoto, A., J. Arnold, J. Ayars, S. Crow, T. Eggeman, L. Jakeway, M. Karkee, S. Khanal, J. Kiniry, J. Matsunaga, N. Meki, G. Murthy, M. Nakahata, R. Ogoshi, B. Turano, S. Turn, J. Yanagida, Q. Zhang. High-Yield Tropical Biomass for Advanced Biofuels. Sun Grant National Conference, New Orleans, LA, October 3-5, 2012. (http://sungrant.tennessee.edu/NR/rdonlyres/3880A277-C502-4EC9-9DEB-C385186A5C85/3706/214Hashimoto_Andy.pdf).

Takara, D., A.G. Hashimoto, S.K. Khanal. Green processing: a biorefinery perspective. In conference proceedings of Sun Grant National Conference: Science for Biomass Feedstock Production and Utilization, New Orleans, LA, Oct. 2-5, 2012. (http://sungrant.tennessee.edu/NR/rdonlyres/DDF120E1-C312-4065-B095-6EC87BD11DA8/3650/317Khanal_Samir.pdf).

Abstracts, Books, Reports and Theses:

Ogoshi, R., Yanagida, J., Turn, S., Illukpitiya, P., Uehara, G., Turano, B., Brewbaker, J., Carpenter, J., and Kinoshita, C. "Biofuels and Crop Assessment Report," Prepared for Dole Foods and Castle and Cook, 2008.

Turano, B., Ogoshi, R., and Uehara, G., "Can Biofuels from Non-food Sources End the Food Versus Fuel Debate," Solicited paper for the Hawaii Energy Policy Forum, 2008.

Ogoshi, R., B. Turano, Uehara, G., Yanagida, J., Illukpitiya, P., Brewbaker, J., and Carpenter, J. 2010. Evaluation of cellulosic feedstocks for biofuel production. In Khanal, S.K., R.Y. Surampalli, T.C. Zhang, B.P. Lamsal, and R.D. Tyagi (eds.) Biofuel and bioenergy from biowastes and biomass. ASCE, Reston, VA.

CH2MHill. Puunene Mill Landfill Gas Utilization Evaluation Report, prepared for Hawaiian Commercial & Sugar Company. Final Report. November 2011.

Sakuda, Merissa H. Estimating a Net Energy Value for Biofuel from Agriculture Biomass Production in Hawaii, M.S. Thesis, Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, December 2011.

PUBLICATIONS/PRESENTATIONS

Abstracts, Books, Reports and Theses (continued):

HNU-ENERGY, Evaluation of Alternative Energy Generation for Hawaiian Commercial & Sugar Company. Final Report. October 17, 2012.

Takara, D., *Green Processing of Napier Grass for Generation of Biofuel and Biobased Products*. PhD dissertation, University of Hawaii at Manoa. Ann Arbor: ProQuest/UMI. 2012.

Yudai Sumiyoshi, M.S. Plan A, Thesis option, "Belowground carbon cycle of Napier and Guinea grasses grown for sustainable biofuel feedstock production", degree awarded December 2012.

Hironao Yamazaki, M.S. Plan B, Capstone Project Title "Alteration in soil carbon pools following land use and management change for bioenergy feedstock production," degree awarded December 2013.

Meghan Pawlowski, M.S. Plan A, Thesis option, "Greenhouse gas flux and fine root dynamics of sugarcane and Napier grass under deficit irrigation," degree awarded May 2013.

Mochizuki, Junko, John Yanagida, and Makena Coffman. 2013. Market, Welfare and Land-use Implications of Lignocellulosic Bioethanol in Hawaii, UHERO Working Paper No. 2013-10, November, 2013.

Norris Energy Crop Technology. Evaluation of Alternative Sugarcane Production Systems – Strategies for Trash Recovery in Both One Year and Two Year Cane in Hawaii. Final Report, January, 2013.

Shaochun Ma, Manoj Karkee, and Qin Zhang. 2013. Sugarcane harvesting system: a critical review, ASABE Paper No. 131574361. ASABE St. Joseph, Mich.

Sierra Research. Evaluation of Alternative Renewable Biomass Fuels for HC&S Boilers. Final Report, April 2013.

McDaniel, A., Murthy, G.S. and Hashimoto, A. 2014. Development of An Life Cycle Impact Assessment Method Based on GBEP indicators. ASABE Abstract No. 1909170. ASABE St. Joseph, Mich.

Abstracts, Books, Reports and Theses (continued):

McDaniel, A., Murthy, G.S. and Hashimoto, A. 2014. Evaluation of Environmental Impacts of Biofuels from Sugarcane and Napier Grass Produced in Hawaii. ASABE Abstract No. 1909313. ASABE St. Joseph, Mich.

Mochizuki, J., Kumar, D., Yanagida, J.Y., Hashimoto, A., and Murthy, G.S. 2014. A. Life cycle assessment of tropical banagrass (Pennisetum purpureum) derived ethanol as transportation fuel in Hawaii. ASABE Abstract No. 1909948. ASABE St. Joseph, Mich.

Stern, I.R., and B. DeBaryshe. On-farm Renewable Energy and Sustainable Local Food Production: A Case Study. University of Hawaii, Center on the Family, Honolulu, HI. 2014. (http://uhfamily.hawaii.edu/publications/brochures/bb683_14101001_COF_ResearchReport-FINAL%20(Jan%2021%202014).pdf)

Presentations and Posters:

Cui, H., S.Q. Turn, and T. Tran. 2010. Biomass pretreatment for gasification. Presented at the 8th International Symposium on Gas Cleaning at High Temperature, August 23-25, 2010 – Taiyuan, Shanxi, People's Republic of China.

Hashimoto, Andrew, Steven Chiang, Susan Crow, Samir Khanal, Charles Kinoshita, Richard Ogoshi, Wei Wen Su, Gordon Tsuji, Brian Turano, Scott Turn, Goro Uehara, and John Yanagida. 2010. Development of High-yield Tropical Feedstocks and Biomass Conversion Technologies. World Congress on Zero Emissions Initiatives, Honolulu, Hawaii, September 13-17, 2010.

Hashimoto, Andrew. 2010. "High Yield Tropical Biomass Feedstock and Renewable Energy for Rural Economic Development." Presented at the BIO Pacific Rim Summit on Industrial Biotechnology & Bioenergy, December 11-14, 2010. Honolulu, Hawaii.

Hashimoto, Andrew. 2010. "University of Hawaii Bioenergy Program." Presented at the BIO Pacific Rim Summit on Industrial Biotechnology & Bioenergy, December 11-14, 2010. Honolulu, Hawaii.

PUBLICATIONS/PRESENTATIONS

Presentations and Posters (continued):

Khanal, S.K. 2010. Biomass conversion to biofuels. Chonnam National University, May 4, 2010, Gwanju, South Korea.

Illukpitiya, P. Economic competitiveness of biofuel feedstock production in Hawaii. Presented at the Dalian Nationalities University, Jinzhou, Dalian, Liaoning, People's Republic of China (October 25 - 26, 2010).

Ogoshi, Richard. 2010. Biofuel crop evaluation. Presented at the Waimanalo Field Day, November 19, 2010, Waimanalo Research Station, Waimanalo, Hawaii.

Reeves, Mataia and Susan Crow. 2010. Carbon sequestration in soils: Assessing the potential for offsetting CO2 emissions through soil conservation. The World Congress on Zero Emissions Initiatives: Launching the "Blue Economy". Honolulu, HI. September 2010.

Reeves, Mataia and Susan Crow. 2010. "Assessing the Potential Carbon Sequestration of Hawai'i's Soils Used for Bioenergy Feedstock Production: An Investigation of Soil Fractionation Methods". CTAHR Student Research Symposium, University of Hawaii, Honolulu, HI.

Smith, Leanna and Scott Turn. 2010. "Net energy analysis of bioenergy feedstock production of Eucalyptus" CTAHR Student Research Symposium, University of Hawaii, Honolulu, HI

Sumiyoshi, Y. and S. E. Crow. Estimation of spatial, diurnal, and species/varietal differences in soil CO_2 efflux from biofuel feedstock plots. Soil Science Society of America Annual Meeting, Long Beach, CA, October 2010. (Contributed poster)

Sumiyoshi, Yudai, S. Crow, B. Turano, and R. Ogoshi. 2010. "Estimation of Spatial, Diurnal, and Species/Varietal Differences in Soil CO_2 Efflux from Biofuel Feedstock Plots" , CTAHR Student Research Symposium, University of Hawaii, Honolulu, HI

Takara, Devin and Samir Khanal. 2010. "Wet processing of adolescent Pennisetum purpureum for enhanced sugar release and co-product generation" , CTAHR Student Research Symposium, University of Hawaii, Honolulu, HI

Presentations and Posters (continued):

Tome, Maria, Cecily Barnes, Andrew Hashimoto. 2010. "Why Biomass & Biofuels for Hawaii?" Panel presentation at the Hawaii Biomass and Bioenergy Workshop, Sep. 24, 2010. Honolulu, Hawaii.

Hashimoto, Andrew. 2011. "Sustainable Bioenergy Systems for Hawaii." Presented at the World Congress of Bioenergy, April 25-30, 2011. Dalian, China.

Khanal, S.K. 2011. "Green processing of a tropical grass for advanced biofuel and biobased products." New Horizons in Biotechnology, Mini Symposia in Biofuels - Current perspectives and challenges for commercialization, November 21-24, 2011, Trivendrum, India.

Khanal, S.K. 2011. "Biorefinery for Hawaii." NC 1023: Engineering for Food Safety and Quality, USDA Multi-state Committee Meeting, October 3, 2011, Honolulu, HI.

Ogoshi, Richard, and Joshua Neipp. 2011. Power Plants. CTAHR Agriculture Awareness Day for Elementary School Students, February 17, 2011, Pearl City Urban Garden Center, Pearl City, Hawaii.

Pawlowski, M., S. E. Crow, Y. Sumiyoshi, J. Wells, and H. Kikkawa. Greenhouse gas flux under warm-season perennial C_4 grasses across different soil and climate gradients on the Islands of Hawaii. American Geophysical Union Annual Meeting, San Francisco, CA, December 2011. (Contributed abstract)

Sumiyoshi, Y., S. E. Crow, C. M. Litton, and J. L. Deenik. Belowground carbon cycle of Napier and Guinea grasses. American Geophysical Union Annual Meeting, San Francisco, CA, December 2011. (Contributed abstract)

Takara, D. and S.K. Khanal. Wet processing of banagrass: A biorefinery perspective. American Society of Agricultural and Biological Engineers (ASABE) 2011 Annual International Meeting, Louisville, KY, USA, August 7-11, 2011.

Hashimoto, A. G. Farming and Energy: Sustainability in America. National Association of State Energy Officials, Minneapolis, MN, September 10-12, 2012.

PUBLICATIONS/PRESENTATIONS

Presentations and Posters (continued):

Hashimoto, A.G. and G. S. Murthy. Biofuels Sustainability Assessment. S-1041-The Science and Engineering for a Biobased Industry and Economy Annual Meeting and Symposium, Waterfront Center (USDA), Washington, DC, August 6-7, 2012.

Meki, M., J. Kiniry, A. Youkhana, M. Nakahata, S. Crow, R. Ogoshi, and J. Steiner. ALMANAC model parameterization for high biomass bioenergy crops. American Society of Agronomy Annual Meeting, Cincinnati, OH, October 21-24, 2012.

Pawlowski, M., S. E. Crow, J. L. Deenik, C. Evensen. Linking soil and water conservation practices to greenhouse gas flux and fine root dynamics: A comparison of sugarcane and Napier grass grown for bioenergy production. ASA, CSSA, and SSSA International Annual Meetings, Cincinnati, OH, October 2012.

Robertson, N., Turano, H., and Turano, B. Genetic Characterization of Hawaiian Napiergrass. CTAHR Student Research Symposium, April, 17, 2012. *Poster presentation won CTAHR Merit Award (3rd place out of 65).

Sumiyoshi, Y., S. E. Crow, C. M. Litton, J. L. Deenik, B. Turano, and A. Taylor. Belowground carbon cycle of Napier and Guinea grasses grown for biofuel feedstock production. ASA, CSSA, and SSSA International Annual Meetings, Cincinnati, OH, October 2012.

Takara, D., A. G. Hashimoto, and S.K. Khanal. Green processing of dedicated energy crops for biofuel and biobased products. International Conference on Challenges in Environmental Science and Engineering (CESE) 2012, Melbourne, Australia, September 9-13, 2012.

Takara, D., A.G. Hashimoto, and S. K. Khanal. Green processing of high yield tropical grass for biofuel and biobased products. S-1041-The Science and Engineering for a Biobased Industry and Economy Annual Meeting and Symposium, Waterfront Center (USDA), Washington, DC, August 6-7, 2012.

Presentations and Posters (continued):

Takara, D. and S.K. Khanal. Green processing of tropical feedstocks for biofuel and biobased products. College of Tropical Agriculture and Human Resources Research Symposium, Honolulu, HI, April 13-14, 2012.

Hashimoto, A. High-Yield Feedstock and Biomass Conversion Technology for Renewable Energy and Economic Development. U.S. Department of Energy Bioenergy Technologies Office Project Peer Review, Alexandria, VA, May 20, 2013.

Hashimoto, A. University of Hawaii Bioenergy Project. S-1041-The Science and Engineering for a Biobased Industry and Economy Annual Meeting. Kahului, Maui. June 17, 2013.

Hashimoto, A. Conversion of High-Yield Tropical Biomass into Sustainable Biofuels. Green Initiative for Fuels Transition Pacific (GIFTPAC, working group of the U.S. Department of Defense Joint Forces Pacific Command) working group meeting. Honolulu, HI. June 21, 2013.

Jakeway, Lee. 2013. "Biofuel Outlook at HC&S Co." Presented at the Asia Pacific Clean Energy Summit and Expo, September 9-11, 2013. Honolulu, Hawaii.

Meki, M. N., J. R. Kiniry, A. Youkhana, M. Nakahata, R. Ogoshi, and S. E. Crow. Key crop parameters for ALMANAC modeling of high biomass energy sorghum growth and productivity. ASA, CSSA, and SSSA International Annual Meetings, Tampa, FL, November 2013. (Contributed poster)

Mochizuki, Junko, John F. Yanagida, Richard Ogoshi, Tomoaki Miura, and PingSun Leung. "GIS analysis of an optimal plant location—the case of Banagrass-based bioethanol production in Hawaii." Paper presentation, College of Tropical Agriculture and Human Resources, Student Research Symposium, University of Hawaii, April 12-13, 2013.

PUBLICATIONS/PRESENTATIONS

Presentations and Posters (continued):

Mochizuki, Junko, John F. Yanagida, Devin Takara, Deepak Kumar, and Ganti S. Murthy. "Life cycle assessment of ethanol production from tropical Banagrass (Pennisetum purpureum) using green and non-green processing technology in Hawaii." Poster presentation, College of Tropical Agriculture and Human Resources, Student Research Symposium, University of Hawaii, April 12-13, 2013.

Ogoshi, R., A. Youkhana, L. Jakeway, M. Nakahta, and P. Shingaki. Feedstock Crop Trials for Hawaii and the Tropics. S-1041- The Science and Engineering for a Biobased Industry and Economy Annual Meeting, Kahului, Maui, HI, June 17-18, 2013.

Youkhana, A., S. E. Crow, M. N. Meki, J. R. Kiniry, R. Ogoshi, and M. Nakahata. Belowground biomass and C dynamics in sugarcane and ratooning energycane cultivated as biofuel production in Hawaii. ASA, CSSA, and SSSA International Annual Meetings, Tampa, FL, November 2013. (Contributed poster)

Hashimoto, Andrew, Richard Ogoshi, Devin Takara, Samir Khanal, Susan Crow. High-Yield Tropical Feedstocks for Bioenergy Production. European Biomass Energy Conference, Hamburg, Germany, June 23-26, 2014.