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

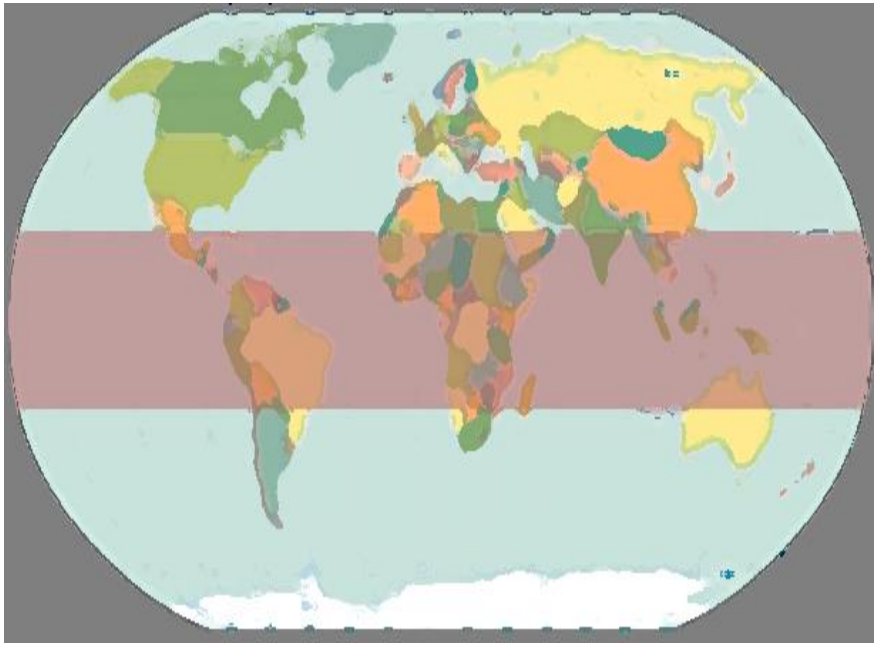
2013 DOE Bioenergy Technologies Office (BETO) Project Peer Review

Andrew G. Hashimoto
University of Hawaii

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 BEPO goal to "Develop sustainable technologies to proved a secure, reliable, and sustainable biomass feedstock supply for the U.S. bioenergy industry, in partnership with USDA and other key stakeholders."

QUAD CHART OVERVIEW

Timeline

Start: 7/30/2008

End: 9/30/2013 Completed: 80%

End: 6/30/2014 ONR

End: 5/31/2016 BRDI

Budget	DOE	Total
FY2008:	$492K	$615K
FY2009:	$1.4M	$1.8M
FY2010:	$6.0M	$8.1M
TOTAL	**$7.9M**	**$10.5M**

Budget	ONR	Total
FY2011:	$991K	$991K

Budget	BRDI	Total
FY2012:	$6.0M	$7.5M
TOTAL	**$14.9M**	**$19.0M**

BEPO Barriers Addressed

- Feedstocks availability and cost.
- Sustainable feedstock production.
- Feedstock quality and monitoring.
- Material properties.

Partners

Hamakua Springs Water

Hawaiian Commercial & Sugar

Office of Naval Research

- USDA/ARS

USDA/NIFA/BRDI

- Oregon State University
- Washington State University
- ZeaChem

PROJECT OVERVIEW

HISTORY:

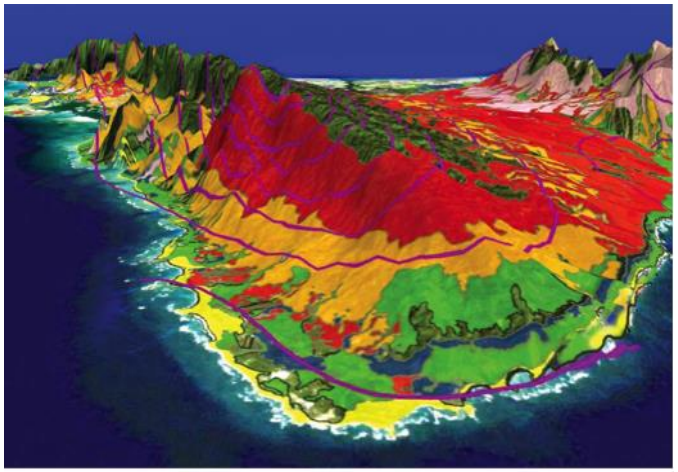
- Started in 2008 as a Congressionally Directed project to assist the Hawaii Clean Energy Initiative.

CONTEXT:

- Strategic location re: "Asia-Pacific Pivot"
- >90% of Hawaii's energy needs depend upon 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



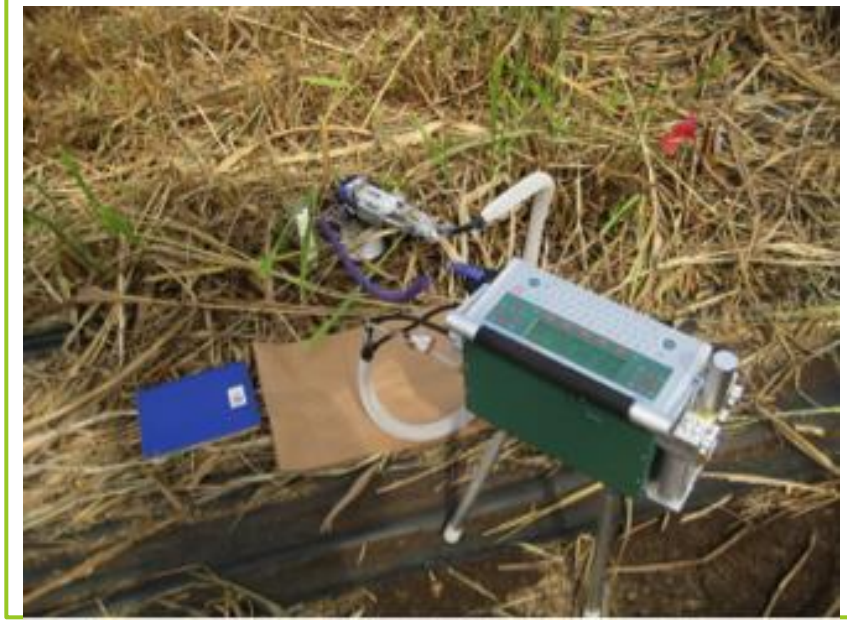
Source: Deenik

APPROACH

- Feedstocks for biofuels:
  - 4 energy crops @ 3 elevations, 3 irrigation levels
  - 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

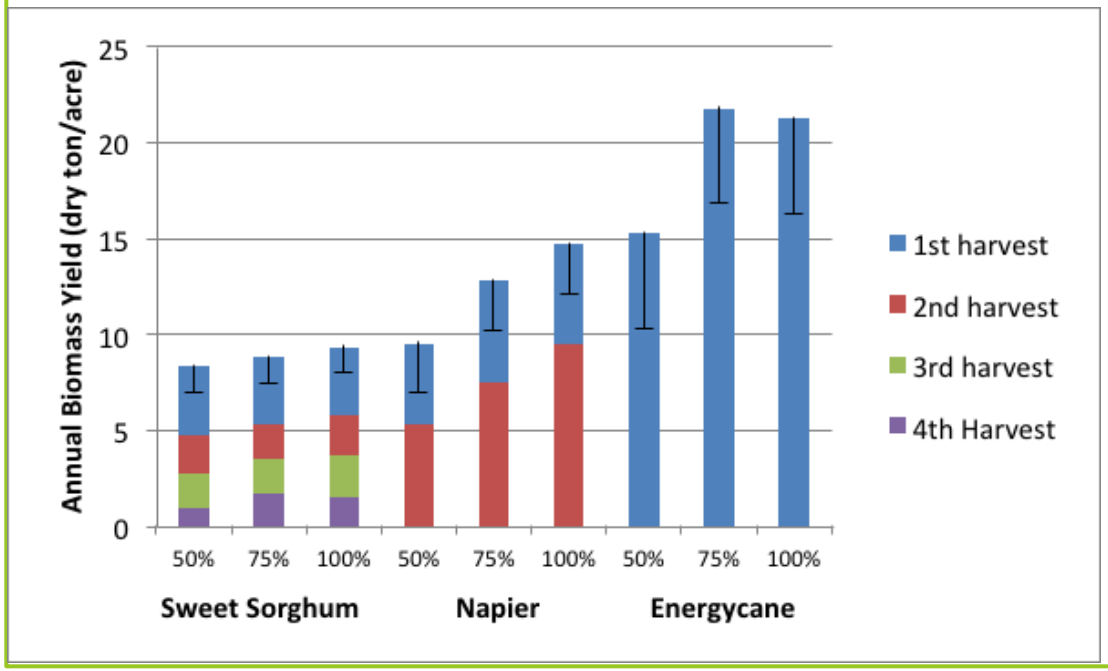
- Simple sequence repeat markers for Napier grass developed.
- Napier grass-by-pearl millet hybrids developed and being evaluated.
- Determined chemical composition of target crops.

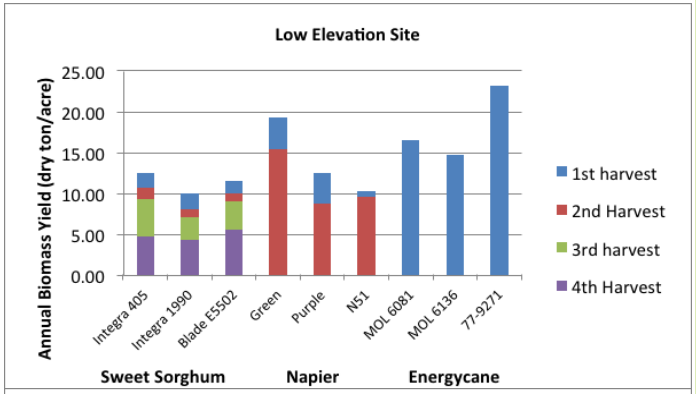


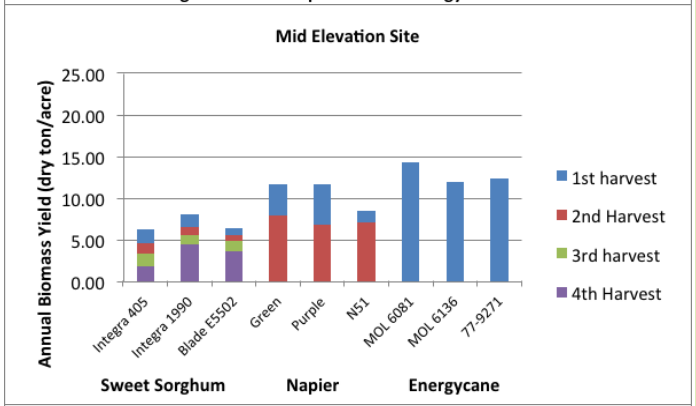
- Methodologies to measure carbon dioxide flux and sequestration have been developed.
- Preliminary results indicate sugar cane a atmospheric C source, while Napier grass a C sink.

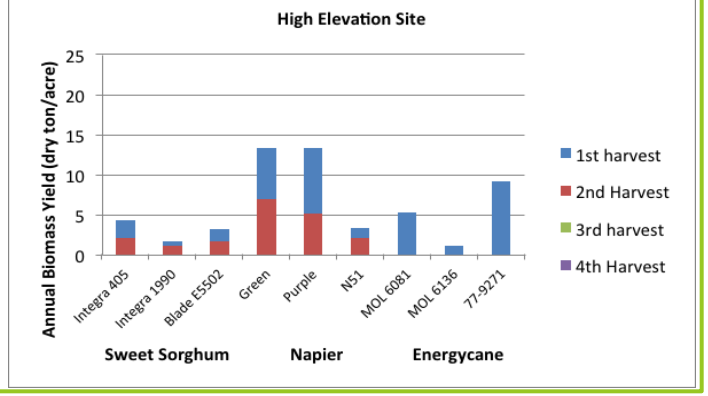
ACCOMPLISHMENTS

- Strong environmental effect on genotype performance.
- Water affects some crops more that others.
- Harvesting frequency is a consideration.









ACCOMPLISHMENTS

- Green processing of feedstock has pros and cons:

  \+ Nutrients, min. storage, continuous processing, co-products.

  \- High moisture, nutrients.
- Feedstock pre-processing required.
- Techno-economic analyses needed.
- Life cycle analyses needed.

RELEVANCE

Relevance to Biomass Program Multi-Year Program Plan:

- Develop feedstocks, sustainable agronomic practices, and feedstocks production processes and systems.
- Develop, test and demonstrate sustainable feedstocks logistics systems.

Applications of Expected Project Outputs:

- Results applicable to a vertically integrated 35,000 acre agribusiness.
- Hawaiian Electric Company and other utilities currently seeking local biofuel.
- Results applicable to regional allies in the Asia-Pacific region.
  - Australia (biofuels)
  - Papua New Guinea (biopower)
- Department of the Navy's Great Green Fleet Initiative

CRITICAL SUCCESS FACTORS

Success Factors

- Comprehensive study
- Integrated analyses
- Focus on feedstocks relevant to the tropics
- Partners with expertise, resources, and production readiness

Challenges

- Coordinating project tasks and deliverables.
- Research vs Development.

Advancing Technology

- Identification and baseline of new feedstocks
- Predicting tropical biomass production that is of strategic importance
- Baseline for environmental sustainability in tropical environments

FUTURE WORK

- Continue multi-year energy crop trials
- Complete feedstock characterization for biochemical and thermochemical conversion to biofuel
- Terrestrial carbon stock and dynamics
- Net energy productivity of tropical bioenergy crops
- Economic impact of low-cost electricity to increase food production and employment opportunities in a rural community
- Develop and validated crop simulation models
- Techno-economic and life cycle assessments.

SUMMARY

- Strategic importance for the Nation and the tropics.
- Comprehensive in scope.
- 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.

ADDITIONAL SLIDES

RESPONSES TO PREVIOUS REVIEW

This is a lot o money to be spending in a state/area that has limited ability to meet its own renewable liquid fuel needs, let alone the country's needs.

It is clear that Hawaii cannot meet all its energy needs through bioenergy; however, any replacement of imported fossil fuels will benefit the Hawaiian economy and reduce the carbon footprint of this remote island community. Before any commercial-scale bioconversion facilities are planned, we must determine whether feedstock can be grown sustainably (economically, environmentally and community friendly), and that the feedstock characteristics are compatible with the planned conversion processes. Very little research has been conducted on tropical feedstocks, and the results from this research will be useful for growers in Hawaii and many tropical areas of the world. Many large and small land owners are very interested in the results of this project, but the reality is that if biomass feedstocks cannot be grown economically on 35,000 contiguous acres, it will be hard pressed to be economically viable on smaller acreage.

RESPONSES TO PREVIOUS REVIEW

Have they been able to predict the potential of converting the biomass to a viable, economical energy source? Are they adequately addressing he food vs. fuel demands as to the land base that is available?

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 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

Publications:

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

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)

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

Illukpitiya, P., J. F. Yanagida, R. Ogoshi and G. Uehara. 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, 2013.

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.

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

Publications (continued):

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).

Tran, Nghia, Prabodh Illukpitya, John F. Yanagida, and Richard Ogoshi 2011. "Optimizing biofuel production: An economic analysis for selected biofuel feedstock production in Hawaii", *Journal of Biomass and Bioenergy*, 35: 1756- 1764.

Presentations:

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 (continued):

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

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

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.

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).

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", Accepted for presentation at the CTAHR Student Research Symposium, University of Hawaii, April 12-13, 2013

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, Accepted for presentation at the CTAHR Student Research Symposium, University of Hawaii, April 12-13, 2013.

Presentations (continued):

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

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, 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.

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 , 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

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.

PUBLICATIONS/PRESENTATIONS

Presentations (continued):

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

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.

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.

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.

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.