SunGrant INITIATIVE

2012 National Conference

Science for Biomass Feedstock Production and Utilization

Program & Agenda

October 2-5, 2012 • New Orleans, LA

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About the Sun Grant Initiative

The Sun Grant Initiative is a national network of land-grant universities and national laboratories partnering to help build a bio-based economy. Land-grant universities have over 150 years of experience in agricultural and natural resource research, with a network of field-based research sites in every major biogeographic zone in every state and territory of the country. The land-grants have a unique tradition of sharing the results of their research by working with farmers, ranchers and foresters through extension outreach in the community and classroom education efforts. The Sun Grant Initiative builds on this successful history and harnesses the land-grant network to tackle the new challenges of developing bio-based transportation fuels, biopower, and new bio-based products. The Sun Grant Initiative facilitates communication and partnership development between universities, national laboratories, federal and state governments, the private sector and public interest groups.

Our Mission

Through development, distribution, and implementation of bio-based energy technologies, the Sun Grant Initiative will:

- Enhance national energy security.
- Provide opportunities for rural economic development in America's traditional agricultural communities.
- Promote environmentally sustainable and diversified production opportunities for agricultural and forestry resources.
- Encourage further bioenergy research collaboration between government agencies and land-grant colleges and universities.

Thank You

The Sun Grant Initiative would like to thank the United States Department of Energy, the Department of Transportation and the Department of Agriculture for their continued support of the initiative.

Thanks to Our Sponsors

EcoSun Prairie Farms

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Meeting Information

General Meeting Information

All Conference events will be held at the Hilton New Orleans Riverside, located at Two Poydras Street, New Orleans, LA 70130. For hotel information please call 1-504-561-0500.

Registration Services

Registration will be open during the following hours:

Tuesday, October 2, 2012.....6:30 am - 8:30 pm (Jefferson Ballroom)

Wednesday, October 3, 2012.....7:00 am - 8:00 am (Napoleon)

Thursday, October 4, 2012.....7:00 am - 8:00 am (Napoleon)

Badges

Badges should be worn at all official functions of the meeting. If you forget or lose your badge, please obtain a second badge at registration.

Posters

Posters will be on display in the Napoleon throughout the Conference and will be presented during the formal poster session on Thursday, October 4, 6:30 pm - 8:30 pm.

Presenter Information

Sun Grant personnel will be collecting your final presentation slides at the Registration table when you check in for the Conference. Please bring your file on a flash drive, and confirm that the uploaded presentation is correct. The Registration table will be open at the Welcome Reception on Tuesday evening (10/2, 6:30 - 8:30 pm), and during breakfast on Conference days (10/3-10/4, 7:00 - 8:00 am.) Sun Grant personnel will be pre-loading your presentation into one repository and uploading it prior to your session.

Committee Members

Steering Committee

Dr. Terry Nipp
Sun Grant Association
Washington, DC

Dr. Bryce Stokes
Senior Advisor, CNJV/DOE
Golden, CO

Dr. Timothy Rials
Southeastern Sun Grant Center
The University of Tennessee
Knoxville, TN

Dr. James Doolittle
North Central Sun Grant Center
South Dakota State University
Brookings, SD

Dr. Kim Cassel
North Central Sun Grant Center
South Dakota State University
Brookings, SD

Mrs. Jessica McCord
Southeastern Sun Grant Center
The University of Tennessee
Knoxville, TN

Mrs. Rachel Papantonakis
Sun Grant Association
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Programming Committee

Dr. Robb Mitchell
USDA-Agricultural Research Service
Lincoln, NE

Dr. Marilyn Buford
USDA-Forest Service
Washington, DC

Dr. Bryan Jenkins
University of California
Davis, CA

Mr. Richard Shuren
GreenWood Resources, Inc.
Boardman, OR

Dr. Tom Foust
National Advanced Biofuels Consortium
Golden, CO

Dr. Bruce Dale
Michigan State University
Lansing, MI

Dr. Virginia Dale
Oak Ridge National Laboratory
Oak Ridge, TN

Dr. Bill Rooney
Texas A&M University
College Station, TX

Dr. Pradip K. Das
Monsanto
St. Louis, MO

Dr. Richard Hess
Idaho National Laboratory
Idaho Falls, ID

Schedule at a Glance

Time	Ballrooms						
	Jefferson	Napoleon	Versailles	Magnolia	Jasperwood	Oak Alley	Elmwood
Tuesday, October 2							
6:30 – 8:30 pm	**Welcoming Reception & Registration**						
Wednesday, October 3							
7:00 – 8:00 am		**Breakfast & Registration**					
8:00 am - 12:00 pm Break 10:00 – 10:30 am			**Opening Plenary Session**				
12:00 - 1:30 pm		**Lunch**					
Breakout Session I							
1:30 - 5:30 pm Break 3:00 – 3:30 pm			**Session 1-D** Feedstock Conversion	**Session 1-A** Crop Development	**Session 1-B** Biomass Production	**Session 1-C** Biomass Logistics	**Session 1-E** System Sustainability
Thursday, October 4							
7:00 – 8:00 am		**Breakfast & Registration**					
Breakout Session II							
8:00 am - 12:00 pm Break 10:00 – 10:30 am			**Session 2-D** Feedstock Conversion	**Session 2-A** Genetics	**Session 2-B** Feedstock Agronomics	**Session 2-C** Biomass Logistics	**Session 2-E** Sustainability
Breakout Session III							
1:30 - 5:30 pm Break 3:00 – 3:30 pm			**Session 3-C** Models and Metrics	**Session 3-A** Biomass Characterization	**Session 3-B** Feedstock Agronomics	**Session 3-D** Bioenergy System Case Studies	**Session 3-E** Biomass Production
6:30 - 8:30 pm		**Poster Session**					
Friday, October 5							
7:00 – 8:00 am		**Breakfast**					
Breakout Session IV							
8:00 – 10:00 am			**Session 4-E** Feedstock Conversion	**Session 4-A** Biomass Production	**Session 4-B** Feedstock Conversion	**Session 4-C** Extension and Education	**Session 4-D** Algae
10:00 - 10:30 am		**Networking Break**					
10:30 am - 12:00 pm			**Closing Plenary Session**				
12:00 pm Close of Conference							

Agenda

Tuesday, October 2, 2012

6:30 – 8:30 pm

Welcoming Reception and Registration

Room: Jefferson Ballroom

Wednesday, October 3, 2012

6:30 – 8:00 am

Registration

Room: Napoleon

7:00 – 8:00 am

Breakfast

Room: Napoleon

8:00 – 8:15 am

Opening Remarks

Room: Versailles Ballroom
John Ferrell, U.S. Department of Energy Biomass Program
Terry Nipp, Executive Director, Sun Grant Initiative

8:15 - 12:00 pm

Opening Plenary Session

Room: Versailles Ballroom

Break 10:00 – 10:30 am

Moderator: Bill Boggess, Oregon State University

- Joel Stone, President, North America and Global VP of Engineering, Green Biologics Inc.
- Neal Gutterson, President and Chief Executive Officer, Mendel
- John Regalbuto, Department of Chemical Engineering, University of South Carolina
- Cassie Phillips, Vice President, Sustainable Forests and Products, Weyerhaeuser

12:00 - 1:30 pm

Lunch

Room: Napoleon

Moderator: Terry Nipp, Sun Grant Initiative

- Neilson C. Conklin, President, Farm Foundation

1:30 - 5:30 pm

Breakout Session 1

Break 3:00 – 3:30 pm

Session 1-A – Crop Development

Room: Magnolia

Moderator: Vance Owens, South Dakota State University

- Brian Baldwin, Regional Testing of Energycane (Saccharum SPP) Genotypes as a Potential Bioenergy Crop
- Daniel Keathley, Initial Willow Biomass Yield Trial Results for Michigan
- Xiusheng Yang, Production Potential of Woody Energy Crops in the State of Connecticut, USA
- Chengci Chen, Investigating the Viability of Camellia Sativa as an Energy Crop in Central Montana
- Calvin H. Pearson, Developing Low-Input, High-Biomass, Perennial Cropping Systems for Advanced Biofuels in the Intermountain West
- Pradeep Wagle, Effect of Soil Moisture on Ecosystem Respiration and its Relationship with Soil Temperature in Switchgrass
- Andy Hashimoto, High-Yield Tropical Biomass for Advanced Biofuels

Session 1-B – Biomass Production

Room: Jasperwood

Moderator: Bill Rooney, Texas A&M

- Sam Jackson, Demonstration of On-Farm Production of a Dedicated Energy Crop Incorporating Multiple Varieties of Switchgrass Seed
- Chuansheng Mei, Developing a Low Input Switchgrass Feedstock Production System Harnessing Beneficial Bacterial Endophytes
- Shannon Osborne, Regional Partnership Corn Stover Management Effects On Soil Aggregation and Physical Properties
- John Gill, Agronomic Results from the Sorghum Regional Biomass Feedstock Trial
- Raymond Miller, Short Rotation Energy Plantation Density Effects on Yield and Return on Investment in a Five-Year-Old Hybrid Poplar Trial in Michigan
- Jeff Wright, Bio-energy Forest Plantations for the Southern United States
- Renato S. Pacaldo, Soil CO_2 effluxes in Shrub Willow Biomass Crops Along a 21-Year Chronosequence as Affected by Continuous Production and Crop Removal (TEAR-OUT)

Session 1-C – Biomass Logistics

Room: Oak Alley

Moderator: Richard Hess, Idaho National Laboratory

- Tucker Porter, Comparison of Three Remote Sensing Methods to Predict Above Ground Plant Biomass Production
- James Jeuck, Accurately Assessing Woody Biomass Potential in North Carolina, US
- James Larson, Effects of Outdoor Storage on the Composition of Switchgrass
- Jude Liu, Biomass Bale Compression Investigating the Gain and Loss
- Dale Greene, Improving Woody Biomass Feedstock Logistics by Reducing Ash and Moisture Content
- Mark Eisenbies, Development and Deployment of a Short Rotation Woody Crops Harvesting System Based on a New Holland Forage Harvester and SRC Woody Crop Header
- Steve Taylor, High Tonnage Harvest and Transport Systems for Southern Pine Energy Plantations

Session 1-D – Feedstock Conversion

Room: Versailles Ballroom

Moderator: Sushil Adhikari, Auburn University

- Darren Baker, Carbon Materials from Lignins with Engineered Thermal Properties
- Samir Khanal, Green Processing: A Biorefinery Perspective
- Victor Ujor, Enhancing Butanol Productivity through Improved Utilization of Biomass by Clostridiu beijerinckii NCIMB 8052
- William Gibbons, Fed-Batch, Simultaneous Saccharification and Fermentation in a High Solids Bioreactor to Maximize Ethanol Titer
- Jonathan Bovee, Pyrolysis of North-American Grass Species: Effect of Feedstock Composition and Location
- Hanno Richter, A Two-Stage Continuous Fermentation System for Conversion of Syngas into Ethanol
- Tom Elder, Gasification of Southern Forest Resources

Session 1-E – System Sustainability

Room: Elmwood

Moderator: Marilyn Buford, USDA-Forest Service

- Virginia Jin, Influence of Corn Stover Harvest on Soil Quality Assessments at Multiple Locations Across the U.S.
- Douglas Karlen, Corn Grain, Stover Yield and Nutrient Removal Validations as Regional Partnership Sites
- Jared Abodeely, A Multi-Factor Analysis of Sustainable Agriculture Residue Removal Potential
- Eleanor Campbell, Using DAYCENT to Model the Soil Impacts of Harvesting Corn Stover for Bioenergy
- Jami Nettles, Extent and Distribution of Sustainable Intensive Forest Biofuel Practices
- Evan H. DeLucia, Conversion of Pasture to Energy Cane for Bioenergy is Predicted to Alter Greenhouse Gas Exchange and Soil Carbon
- Chad Hellwinckel, Projecting GHG Emissions from Agriculture: Effects of Shifting Trends in Cellulosic Feedstock Data

Thursday, October 4, 2012

7:00 - 8:00 am Breakfast

Room: Napoleon

8:00 am - 12:00 pm Breakout Session II

Break 10:00 – 10:30 am

Session 2-A – Genetics

Room: Magnolia

Moderator: Ray Miller, Michigan State University

- Neal Stewart, Field-Based Experiments on Low-Lignin Switchgrass as a Feedstock for Lignocellulosic Biofuel Production
- Erik T Nilsen, Biotechnological Improvement of Switchgrass for Higher Biomass Yield Under Cool Growing Conditions
- Arvid Boe, Quantitative Genetic Analysis of Biomass Yield, Pest Resistance, and Other Agronomic Traits in Prairie Cordgrass and Cup Plant
- Matthew Bartek, QTL for Biomass Yield and Composition in Energy Sorghum (SORGHUM BICOLOR L. MOENCH)
- Bill Berguson, The Sun Grant Poplar Woody Crops Research Program: Accomplishments and Implications
- Jeff Wright, Science Looks to Unlock Potential in the Undomesticated Tree through Precise Genetic Breeding
- Randall J. Rousseau, Development of a Black Willow Improvement Program For Biomass Production in the Lower

Mississippi River Alluvial Valley

Session 2-B – Feedstock Agronomics

Room: Jasperwood

Moderator: Doug Karlen, USDA- ARS-NLAE

- Thomas Voigt, Miscanthus X Giganteus Biomass Feedstock Production and Sustainability Studies in the Eastern U.S.
- Rafiq Islam, Growing Miscanthus for Biofuels on Marginal Land Amended with Sewage Sludge and Flue Gas Desulfurized (FGD) Gypsum
- Leo Hoffmann Jr., Accumulation of Biomass and Compositional Change over the Growth Season for Six Photoperiod Sorghum Lines
- Paul M. White, Green-Cane Harvest of Sugarcane Effects on Biomass and Energy Yields and Nutrient Removal
- Oluseyi Fajolu, Stand Establishment and Biomass Yield of Switchgrass Impacted by Several Soil- and Seed-Borne Fungal Plant Pathogens
- Scott D. Roberts, Early treatment-Related Competitive Effects in a Loblolly Pine – Switchgrass Co-Culture System
- Vance Owens, Switchgrass Response to N Fertilizer Across Diverse Environments in the USA: A Regional Feedstock Partnership Report

Session 2-C – Biomass Logistics

Room: Oak Alley

Moderator: Ray Huhnke, Oklahoma State University

- Edward Yu, Feedstock Costs and Transportation Emissions and Their Impact on the Site Selection of a Switchgrass-Based Biorefinery: A Case Study of Tennessee
- Sunil K. Mathanker, Sensing Miscanthus Stem Bending Force and Swathed Biomass Volume to Predict Yield
- Dana Mitchell, Harvesting Systems and Costs for Short Rotation Poplar
- Richard Hess, Improving Biomass Logistics Cost Within Agronomic Sustainability Constraints and Biomass Quality Targets
- Stephen Searcy, Evaluation of a Modular System for Low Cost Transport and Storage of Herbaceous Biomass
- Sudhagar Mani, A Novel Biomass Granulation Technology for a Modern Biorefinery
- Ian Bonner, Effect of Mechanical Condition on the Thin-Layer Drying of Energy Sorghum (Sorghum bicolor (L.) Moench)

Session 2-D – Feedstock Conversion

Room: Versailles Ballroom

Moderator: Nicole Labbé, The University of Tennessee

- Ajay Kumar, Effects of Biomass Feedstocks, Gasifier Design and Conditions on Physiochemical Properties of BioChar
- Sushil Adhikari, Catalytic Pyrolysis of Torrefied Biomass for Hydrocarbons Production
- Jun Ding, Acetic Acid Inhibition of Lignocellulose-Derived Sugar Platform Fermentations
- Mark A. Eiteman, Microbial Consortia for the Substrate Selective Conversion of Sugars and the Removal of Inhibitors Acetate and Furfural
- Min Hea Kim, Simultaneous Fermentation of Glucose and Xylose by Co-Culture in a Novel Bioreactor
- Cheng-Wei (Tom) Chang, Synthesis of Fluorogenic Model for Bioprospecting of Enzymes that Break Lignin-hemicellulose Bonds
- Wenqiao Yuan, Char-Based Ni Catalysts for Syngas Cleanup and Conditioning in Biomass Gasification

Session 2-E – System Sustainability

Room: Elmwood

Moderator: Jami Nettles, Weyerhaeuser Company

- John M. Baker, Corn Stover Removal Impacts on N_2O Emission and Soil Respiration: Lessons From Automated Chamber Measurements
- Stuart J. Birrel, Sustainable Corn Stover Harvest for Cellulosic Ethanol
- Jane M.F. Johnson, Corn Stover Management Effects on Soil Organic Carbon Contents from Several U.S. Locations
- David R. Huggins, Site-Specific Trade-offs of Harvesting Cereal Residues as Biofuel Feedstocks
- Zakiya H. Leggett, Evaluating the Impact of Switchgrass Intercropping in Loblolly Pine Plantations on Long-Term Soil Productivity
- Tim Volk, Incorporating Uncertainty into Life-Cycle Analysis (LCA) of Short-Rotation Willow (SALIX SPP.) Crops
- Antonio Bento, Current Lifecycle Analysis Methods are Inadequate for Evaluating Climate Mitigation Options

12:00 - 1:30 pm Lunch on your own

1:30 - 5:30 pm Breakout Session III

Break 3:00 – 3:30 pm

Session 3-A – Biomass Characterization

Room: Magnolia

Moderator: John Talbott, Oregon State University

- Keri B. Cantrell, Distribution of Energy Content in Corn Plants as Influence by Corn Residue Management
- Nicole Labbé, Isolation and Characterization of Lignins Through an Ionic Liquid Fractionation Approach
- Lawrence B. Smart, Variation in Biomass Composition and Enzymatic Saccharification for Biofuel Production Among Cultivars of Shrub Willow
- Tina P. Thomas, Comparison of Lignin and Carbohydrate Analysis Using Pyrolysis-Molecular Beam Mass Spectrometry, Pyrolysis-Gas Chromatography Mass Spectroscopy and Wet Chemistry
- Ke Zhang, Chemical and Elemental Composition of Big Bluestem as Affected by Ecotype and Planting Location Along the Precipitation Gradient of the Great Plains
- Spyridon Mourtzinis, Distribution of Structural Carbohydrates in Corn Plants as Influenced by Corn Residue Manag
- Hojae Yi, Determination of Mechanical Properties of Pelletized Biomass and Fundamental Mechanical Properties of Granular Biofeedstock

Session 3-B – Feedstock Agronomics

Room: Jasperwood

Moderator: Jim Doolittle, South Dakota State University

- D.K. Lee, Conservation Reserve Program (CRP) Grassland for Sustainable Biomass Feedstock Production
- Raymond Iglay, Effects of Switchgrass Intercropping and Biomass Harvesting on Plant Communities in Intensively Managed Pine Stands
- Janine Albaugh, Water Relations and Productivity in an Intercropped Pine-Switchgrass Study Examining Biofuel Production in North Carolina, USA
- Paul J. Johnson, Recent Discoveries and Development in the Entomology of Bioenergy Crop Production
- Mark Windham, Epidemiology of Puccinia emaculata (Rust) In Switchgrass
- Nurhan Dunford, Potential of Picochlorum Oklahomensis as Feedstock for Biofuel Production
- Vijaya Gopal Kakani, Energy Beets as a Bioenergy Feedstock in the Southern Great Plains

Session 3-C – Models and Metrics

Room: Versailles Ballroom

Moderator: Steve Taylor, Auburn University

- Laurence Eaton, Beyond the Billion-Ton: Resource Analysis Challenges and Outcomes from the Regional Partnership Resource Assessment Team
- Nicholas Lovrich, Integrating Social Capital into Biojet Feedstock Facility Siting Decisions
- Tim Young, Spatially-Defined Opportunity Zones for Cellulosic Biomass Supply Integrated with the BioSAT Mode
- Edward Yu, Analyzing the Economics of an Alternative Preprocessing Technology in the Switchgrass Logistics System for a Biorefinery in East Tennessee
- Yubin Yang, Development of a Process-Based Herbaceous Bioenergy Crop Model
- Gayathri Gopalakrishnan, Modeling the Impact of Energy Crops on Agricultural Sustainability at the Farm-Scale
- Aaron Myers, Database Infrastructure Development and Maintenance for Sustainable Production of Biomass

Session 3-D – Bioenergy System Case Studies

Room: Oak Alley

Moderator: Rob Mitchell, USDA-Agricultural Research Service

- Bruno Cardoso, Production System of Sugar Cane in São Paulo State - Brazil: A Conceptual Model
- Kevin D. Kephart, Feedstock Opportunities in the North Central Region Drop in Fuels
- Jason Bergtold, Farmers' Willingness to Produce Alternative Cellulosic Biofuel Feedstocks in Kansas Using State Choice Experiments
- Rob Mitchell, A Case Study for Meeting Bioenergy Feedstock Demand in Eastern Nebraska
- John Schelhas, Social Acceptability of Biofuels in the U.S. South
- Ankit Bansal, Economic Competitiveness of Ethanol Production from Cellulosic Feedstock in Tennessee
- Burt English, Potential for Tennessee to Meet a 20% Renewable Transportation Fuel Demand with Herbaceous Crops

Session 3-E – Biomass Production

Room: Elmwood

Moderator: Andy Hashimoto, University of Hawaii

- John Carlson, Studying the Effects on Woody Biomass Productivity of Genotype-by-Environment Interactions
- Kurt Krapfl, Belowground Competitive Interactions within Loblolly Pine-Switchgrass Co-Culture
- Mark Alexander, Phenotypic Variation and Yield Measurements of Three Varieties of 2nd-Year Switchgrass Grown as a Dedicated Energy Crop in East Tennessee
- Chengci Chen, Nitrogen Application and Harvest Timing Affect Biomass Yield and Composition on CRP Grassland
- Michael P. Grisham, Disease Concerns in Energycane
- Girisha Ganjegunte, Cellulosic Bioenergy Crop Production with Marginal Quality Water
- Ryan P. Viator, Energycane Crop Establishment and Flood Tolerance in a Temperate Climate

6:30 – 8:30 pm Poster Session

Room: Napoleon

Agenda

Friday, October 5, 2012

7:00 am - 8:00 am Breakfast

Room: Napoleon

8:00 - 10:00 am Breakout Session IV

Session 4-A – Biomass Production

Room: Magnolia

Moderator: Steve Thomas, U.S. Department of Energy

- Chang Oh Hong, Nitrogen Losses from Switchgrass as Affected by Nitrogen Fertilizer Rate
- Stephen J. Herbert, Evaluating Switchgrass Varieties for Biomass Yield and Quality in Massachusetts
- Matthew Pelkki, Building a Better Biomass Ecosystem: Cottonwood-Switchgrass Agroforests on Marginal Land
- Josh Gamble, Establishment of Perennial Alley Cropping Systems on Riparian Soils for Bioenergy Feedstock Production

Session 4-B – Models and Metrics

Room: Jasperwood

Moderator: Jessica McCord, The University of Tennessee

- David W. Archer, Economics of Residue Harvest: Regional Partnership Evaluation
- Zane R. Helsel, Economic Feasibility of Biofuels Crops in Florida and New Jersey
- Mike Halbleib, Nationwide Crop Suitability Modeling of Biomass Feedstocks
- Mladen Grobovic, Southeastern Regional Atlas of Biomass Feedstock Potential

Session 4-C – Extension and Education

Room: Oak Alley

Moderator: Kim Cassel, South Dakota State University

- Lauren Dowler, Bioenergy & Bioproducts Education Programs (BBEP)
- Michael Jacobson, Transformative Regional Approaches for Northeast Wood Energy
- Sue Hawkins and Jason de Koff, Bioenergy Education and Outreach Through eXtension.org
- Scott D. Scheer, Development and Dissemination of Bioenergy Education Curriculum for Children

Session 4-D – Algae

Room: Elmwood

Moderator: Dorin Boldor, Louisiana State University

- Barbara C. Benson, Mechanistic Model Development of Fundamental Biological and Physiological Processes Governing Lipid Production by Microalgae
- Chandra Theegala, Screening Microalgae Species for Biodiesel Feedstock Production
- Armin R. Völkel, Innovative Algae Dewatering Technology
- Ruanbao Zhou, BioSolar Conversion of CO_2 and H_2O to Long-Chain Alcohols by Engineered Cyanobacteria

Session 4-E – Feedstock Conversion

Room: Versailles Ballroom

Moderator: Tom Elder, USDA-Forest Service, Southern Research Station

- Julie Willoughby, Lignin as a Material Platform for Bio-Derived Macromolecules and Fibers
- Charles Cai, Solvent Systems for Enhanced Furfural and Hydroxymethylfurfural Production from Cellulosic Biomass
- Hasan Jameel, Development of an Effective Hardwood Pretreatment for the Production of Ethanol in a Repurposed Kraft Mill
- Joseph Bozell, Integrating Separation and Conversion – Conversion of Biorefinery Process Streams to Biobased Chemicals and Fuels

10:00 am – 10:30 am Networking Break

Room: Napoleon

10:30 am - 11:00 am Closing Plenary Session

Room: Versailles Ballroom

Moderator: Tim Rials, The University of Tennessee

- Kevin Kephart, South Dakota State University

11:00 am - 12:00 pm Conference Synthesis- What Have We Learned?

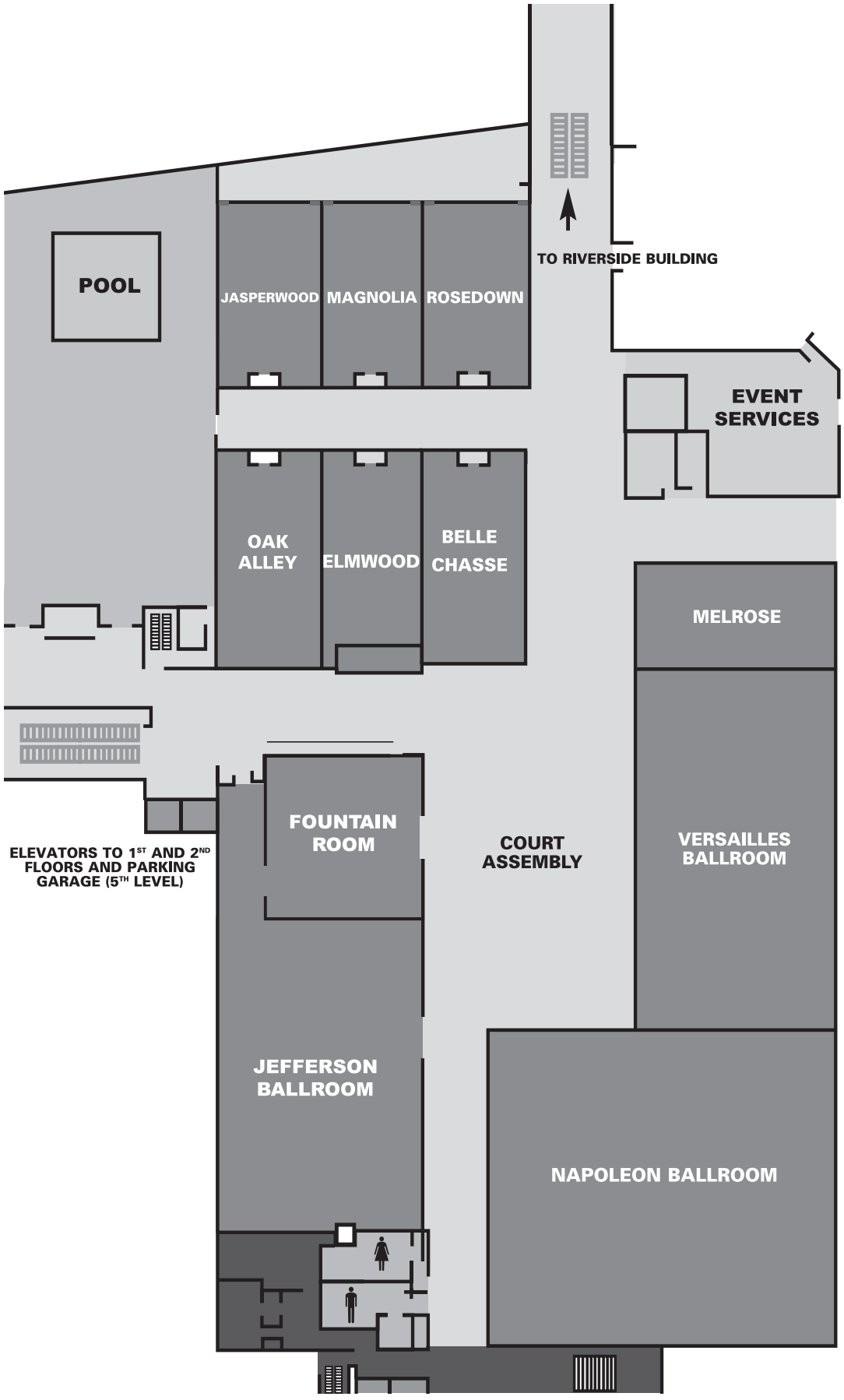
Room: Versailles Ballroom

Moderator: Tim Rials, The University of Tennessee

- Vance Owens, South Dakota State University
- Bryce Stokes, CNJV, DOE

12:00 pm Close of Conference

Floor Plan (Third Floor)



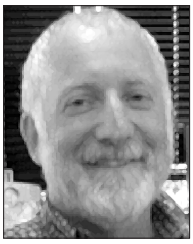
Dr. Neilson C. Conklin
President, Farm Foundation

Prior to joining Farm Foundation inJanuary 2008, Dr. Conklin was director of the Market and Trade Economics Division of USDA's Economic Research Service. The Market and Trade Economics Division provides a broad range of economic research and analysis on global agricultural markets. Prior to his service at USDA, Dr. Conklin was chief economist at the Farm Credit Council.

Between 1984 and 1988, Conklin worked at the USDA Economic Research Service in various capacities including fruit and vegetable outlook and as deputy director of the Agriculture and Trade Analysis Division. He also served as chief of the Agriculture Branch at the Office of Management and Budget and on the faculties of Colorado State University, the University of Arizona and Arizona State University. Conklin received a Ph.D. in agricultural and applied economics from the University of Minnesota. He also holds an M.S. degree in agricultural economics from the University of Wyoming and a B.A. in history from Castleton State College in Vermont.

John Ferrell
U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy Biomass Program

John Ferrell is with the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy Biomass Program, currently working as the Technical Lead and Supervisor for biomass feedstocks. He is responsible for the planning, development, and management of the Feedstock Platform, which is coordinated with the DOE's National Laboratories, as well as a variety of partners including the U.S. Department of Agriculture (USDA), the land grant university system's Sun Grant Initiative, and other representatives from industry and academia. The goal of the Feedstock Platform is to provide a high quality, affordable, and diverse biomass feedstock supply for the Nation's growing biofuels and biomass industry. In previous Biomass Program assignments, Mr. Ferrell worked as Technical Lead for biomass conversion technologies, as well as Co-Director of the National Biomass Coordination Office with USDA. In previous DOE assignments, he served as Director of the Office of Fuels Development. Mr. Ferrell received a bachelor's degree in biology from Kalamazoo College, as well as a master's degree in resources management from Syracuse University and SUNY College of Environmental Science and Forestry.



Neal Gutterson
Chief Executive Officer
Mendel Biotechnology

Neal has been Chief Executive Officer since February 2007. He joined Mendel June 2002 and served as VP, R&D, and then Chief Operating Officer, prior to his appointment as President & COO in December 2005. Neal is also chairman of the Board of Directors. Neal has been involved in plant biotechnology since 1983, when he joined the fledgling biotechnology company AGS, to develop genetically improved microbial biocontrol agents. Before joining Mendel, he spent 18 years at DNAP, where he managed diverse research programs and corporate relationships, and then served as VP, R&D for several years. He is a named inventor on more than 3-dozen patents and pending patent applications. Neal holds a Ph.D. in Biochemistry from the University of California, Berkeley, and a B.S. in Chemistry from Yale University. He also attended the Stanford Graduate School of Business for an executive education program. He serves as a member of the Food and Agriculture Section and the Industrial and Environmental Section Governing Boards of the Biotechnology Industry Organization. He also serves on the steering committee of CSBP, the Council for Sustainable Biomass Production. Neal is a member of the GrassRoots Biotechnology Board of Directors.

Dr. Kevin D. Kephart
Vice President for Research, South Dakota State University

Dr. Kevin Kephart is Vice President for Research at South Dakota State University. Kephart has led national efforts since 2001 to establish the Sun Grant Initiative and he advocates for research and education programs regarding ag-based renewable energy conducted at land grant colleges and universities. He is a Professor in the Department of Plant Science at South Dakota State University. Vice President Kephart received a Ph.D. in crop production and physiology from Iowa State University in 1987. His dissertation research focused on solar control of growth and cell-wall development in perennial grasses. Vice President Kephart also conducted research on production and forage quality of alfalfa, switch grass and other species. Between 1998 and 2005, he served as Associate Dean of the College of Agriculture and Biological Sciences and Director of the South Dakota Agricultural Experiment Station. In 2005 to 2007 Vice President Kephart served as Dean of the Graduate School in addition to Vice President for Research.

Dr. Terry Nipp
Executive Director, Sun Grant Association

Dr. Terry Nipp serves as the Executive Director of the Sun Grant Association (SGA), an organization of land-grant universities leading the Sun Grant Initiative (SGI). The SGI supports research and education efforts on the development of bioenergy and bioproducts. The SGI is collaborating with the Department of Energy to develop and implement the Regional Biomass Feedstock Partnership, which includes the creation of a national inventory of biomass for fuel resources; the development of new GIS tools to map and project locations for optimum agricultural production, processing and distribution of biomass; and, field research plots across the nation to study priority bioenergy crops. With support from the Department of Transportation, the SGI has developed a national program of regional competitive grants for research on renewable transportation fuels. With support from the Department of Agriculture, the SGI is conducting life-cycle analyses on the production of biomass for fuel. The SGI has implemented over $70 million in bioenergy research and is currently supporting over 130 biomass and bioenergy research projects with locations in over 90% of the states and territories. Dr. Nipp has had a wide range of experience in science policy and program development. He served as a Congressional Science Fellow, working on the House Agriculture Committee and the subcommittee with oversight over agricultural research. Dr. Nipp served as a science consultant for the Congressional Office of Technology Assessment, and he worked as a research associate for the National Academy of Sciences / Natural Research Council Board on Agriculture and Natural Resources. For ten years, Dr. Nipp led efforts to develop support for critical issues, such as water quality and food safety, on behalf of National Association of State Universities and Land-Grant Colleges (NASULGC, now APLU). He has joint Bachelors of Art in Political Science and Human Biology from Stanford University, an M.S. in Biology from Stanford and an M.A. from the Stanford Food Research Institute, and his Ph.D. is in Agronomy from Oklahoma State University.

Dr. Vance N. Owens
Professor, South Dakota State University

Dr. Vance Owens received BS, MS, and PhD degrees at Brigham Young University, Utah State University, and the University of Wisconsin-Madison, respectively. He has conducted research on perennial grasses for forage or bioenergy for more than 15 years. He is primarily working with grasses native to the northern Great Plains, and is particularly interested in how we can manage biomass crops across the landscape. He leads the herbaceous group within the Regional Feedstock Partnership, a Sun Grant/DOE partnership evaluating various herbaceous species across the US. He also currently serves as interim Director of the North Central Sun Grant Center at South Dakota State University.

Cassie Phillips

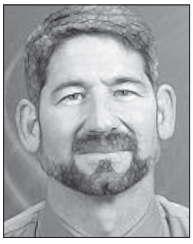
Vice President, Sustainable Forests and Products, Weyerhaeuser

Cassie is an internationally recognized expert on sustainable forestry. She is Weyerhaeuser's strategist on forest stewardship and forest certification, and an advocate in relationships with governments, environmental groups, customers, and other stakeholders.

Cassie has over 25 years of experience in environmental negotiations and public policy. She has played a leading role in consensus agreements among diverse stakeholders, including indigenous peoples, government agencies, industrial and family forest owners, and environmental non-governmental organizations. She is on the Visiting Committee for the University of Washington's School of Environmental and Forest Sciences, is a member of the board of the Keystone Center "http://www.keystone.org/", and serves on The Nature Conservancy's Business Council. She served on the steering committee for The Forests Dialogue, a multi-stakeholder forum seeking new solutions to global forestry issues, "http://research.yale.edu/gisf/tfd/".

Cassie joined Weyerhaeuser in 1991 and has served in regional and international positions in Weyerhaeuser's Timberlands organization. Cassie came to Weyerhaeuser from the Seattle law firm Perkins Coie, where she specialized in business and natural resource law. Before that, she was legislative assistant to U.S. Senator Slade Gorton and chief counsel to the Senate Commerce Committee's sub-committee on Science, Technology and Space. She began her career as a forester and a local manager for the Washington Department of Natural Resources.

Cassie graduated with honors from the University of Washington with degrees in forestry (1976) and law (1982). She was editor-in-chief of the Washington Law Review. Cassie is married with two grown children, grows her family's vegetables, and has never had a synthetic Christmas tree.



Dr. John Regalbuto

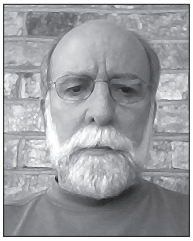
Professor, University of South Carolina

Dr. John Regalbuto is Professor and CoEE Endowed Chair in the Department of Chemical Engineering at the University of South Carolina. Dr. Regaluto's research focuses on the study of the preperation of solid catalysts. He was a Professor in the Department of Chemical Engineering at the University of Illinois at Chicago. Dr. Regalbuto also has served as the Director of the Catalysis and Biocatalysis Program in the Engineering Directorate at the National Science Foundation. He was the lead co-chair of the Biomass Conversion Interagency Working Group, which reports to the National Biomass R&D Board. John's education includes a B.S. in Chemical Engineering from Texas A&M University in 1981, an M.S. in Chemical Engineering from the University of Notre Dame in 1983 and a Ph.D. from Notre Dame in 1986.

John has several hundred research publications and presentations, and most recently has edited one of the few books in his research specialty, catalyst preparation. He has twice served as President of the Catalysis Club of Chicago, and has been active organizing symposia on catalysis for meetings for the American Institute of Chemical Engineers and the American Chemical Society.

Dr. Bryce Stokes
Senior Advisor, CNJV/DOE

Dr. Stokes has over 34 years of experience in R&D and program management. His research has focused on forest harvesting machine and system design and management; biomass recovery and utilization; environmental impacts reduction; carbon accounting; carbon sequestration management; climate change issues; forest productivity and genomics; short rotation woody crops; life cycle analysis; and sustainability criteria and indicators. His experiences include as a Forest Engineer for Weyerhaeuser Company, and a Research Engineer, Project Leader, and National Program Leader for the USDA Forest Service. Since his federal retirement, he has been providing technical and analytical support to the Biomass Program as a Senior Advisor with CNJV. He has held leadership positions in several departmental and interagency bioenergy and climate change working groups. He served as a Congressional Fellow in 2002. Dr. Stokes has held national leadership positions in the Council on Forest Engineering, Forest Products Society, and the American Society of Agricultural and Biological Engineers. He served as a U.S. representative or as Task Lead or Associate Task Lead for several International Energy Agency Tasks for about 20 years. He has over 140 scientific and technical publications. He co-led the update of the Billion Ton Report. He received his BS and MS from Mississippi State University in Engineering and PhD from Auburn University in Forestry.



Joel A. Stone
President, Green Biologics Inc.

Joel has been a long term visionary and respected leader in commercialization of industrial biotechnology. Joel is the President of Green Biologics Inc. where he is leading the development of the commercial platform of the company in North America for renewable n-butanol for use in the renewable chemical markets and ultimately “drop in” biofuels. He also serves as Vice President Global Engineering for Green Biologics Limited based in Abingdon, England. Prior to the merger in 2011 with Green Biologics and his current role, Joel was CEO of butylfuel™ Inc. Previously he was responsible for leading Osage Bio Energy in establishing new products and business opportunities where as the company Chief Operations Officer he was instrumental in bringing BioRefining to the forefront of biofuel facilities. Joel has served as the Chief Operating Officer for both AS Alliances Biofuels LLC and previously Abengoa Bioenergy Corporation. During his tenure with ASAlliances, Joel’s accomplishments included the planning, construction, and startup of three 100 MMGPY fuel grade ethanol plants. Mr. Stone provided operations leadership as Vice President of Operations of Balchem Corporation, a manufacturer of controlled release food ingredients and animal feed nutrients; and 11 years as Vice President of Operations for Opta Food Ingredients, a developer and manufacturer of functional starch, protein, and fiber ingredients. Earlier in his career Joel served as Director of Manufacturing for Genencor, a biotechnology developer and manufacturer of food and industrial grade enzymes. During the 1980’s Mr. Stone provided leadership in the design, startup, and operation of three fuel ethanol facilities. Mr. Stone holds a B.S. in Chemical Engineering from Virginia Polytechnic University; and an M.S. in Chemical and Biochemical Engineering from the University of Pennsylvania. Joel serves on the Board of Directors for Green Biologics Limited.

Abstracts

A MUTLI-FACTOR ANALYSIS OF SUSTAINABLE AGRICULTURAL RESIDUE REMOVAL POTENTIAL

Jared Abodeely[a], David Muth[a], Paul Adler[b], Eleanor Campbell[c], Kenneth Bryden[d]

Agricultural residues have significant potential as a near term source of cellulosic biomass for bioenergy production, but sustainable removal of agricultural residues requires consideration of the critical roles that residues play in the agronomic system. Previous work has developed an integrated model to evaluate sustainable agricultural residue removal potential considering soil erosion, soil organic carbon, greenhouse gas emission, and long-term yield impacts of residue removal practices. The integrated model couples the environmental process models WEPS, RUSLE2, SCI, and DAYCENT. This study uses the integrated model to investigate the impact of interval removal practices in Boone County, Iowa, US. Residue removal of 4.5 Mg/ha was performed annually, bi-annually, and tri-annually and were compared to no residue removal. The study is performed at the soil type scale using a national soil survey database assuming a continuous corn rotation with reduced tillage. Results are aggregated across soil types to provide county level estimates of soil organic carbon changes and individual soil type soil organic matter content if interval residue removal were implemented. Results show interval residue removal is possible while improving soil organic matter. Implementation of interval removal practices provide greater increases in soil organic matter while still providing substantial residue for bioenergy production.

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CATALYTIC PYROLYSIS OF TORREFIED BIOMASS FOR HYDROCARBONS PRODUCTION

Vaishnavi Srinivasan[a], Sushil Adhikari[a], Shyamsundar Ayalur Chattanathan[a], Sunkyu Park[b]

Fast pyrolysis process is one of the promising techniques that produces high liquid yield. However, pyrolysis liquid (bio-oil) is unstable, and has high oxygen content (~35 wt.%), which restricts its use as a transportation bio-fuel. A number of upgrading techniques have been experimented over the last two decades to improve the quality of the liquid product-- primarily to reduce the oxygen content-- but those processes still suffer from several technical challenges. A simple thermal pretreatment process called torrefaction has shown to be effective in reducing the oxygen content in biomass to a certain extent. The main objective of this study was to integrate torrefaction with fast pyrolysis process to produce high quality of bio-oil. In this study, the effects of four pyrolysis temperatures (450, 500, 550 and 600°C), and shape-selective zeolite catalyst (H^+ZSM-5) on hydrocarbon yield were analyzed.

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WATER RELATIONS AND PRODUCTIVITY IN AN INTERCROPPED PINE-SWITCHGRASS STUDY EXAMINING BIOFUEL PRODUCTION IN NORTH CAROLINA, USA

Janine M. Albaugh[a], Jean-Christophe Domec[a], Chris A. Maier[b], Eric B. Sucre[c], Zakiya H. Leggett[c], John S. King[a]

Our project aims to develop a new, multifunctional bioenergy production system of traditional loblolly pine (Pinus taeda L.) grown for solid wood products intercropped with switchgrass (Panicum virgatum L.) for biofuel production that will be broadly applicable throughout the Southeast U.S. To this end, a long-term field experiment was implemented on the Lower Coastal Plain of North Carolina by Catchlight Energy, LLC, a joint venture between Chevron and Weyerhaeuser Company as part of a sustainability research platform relative to conversion of non-food biomass into liquid transportation fuel. As there were no data on water use of switchgrass and pine when grown together, we examined seasonal diurnal water relations during 2011 in these species grown alone, and in combination, to determine the effect of intercropping on water availability. There was no effect of intercropping on water relations; however, there was a significant species effect (switchgrass had higher photosynthesis and stomatal conductance rates, and experienced less water stress compared to pines). Maximum photosynthetic rates measured in June were 3.7 ± 0.1 μºmol m-2 s^{-1} for pine, and 18.4 ± 3.6 μmol m^{-2} s^{-1} for switchgrass; corresponding values for October were 6.3 ± 0.3 μmol m^{-2} s^{-1} and 15.6 ± 1.0 μmol m^{-2} s^{-1}. There was no effect of intercropping on switchgrass biomass which measured 4.5 ± 1.3 Mg ha^{-1}. We will use these data to parameterize a soil plant- atmosphere model which predicts canopy water use and productivity, allowing us to determine the effect of intercropping on water and carbon uptake.

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PHENOTYPIC VARIATION AND YIELD MEASUREMENTS OF THREE VARIETIES OF 2ND-YEAR SWITCHGRASS GROWN AS A DEDICATED ENERGY CROP IN EAST TENNESSEE

Mark Alexander[a], Samuel Jackson[a], Nicole Labbé[a]

The aim of this study was to test the suitability of three varieties of switchgrass (Panicum virgatum L.) to east Tennessee as well as to analyze physiological and productive variation across three locations. We determined stand establishment, tiller height, tiller diameter,

and number of tillers for three switchgrass varieties grown on three farms in east Tennessee. Variety trials were established in 2010 and were harvested in winter 2012. A total of 72.2 ha were planted, consisting of 24.1 ha each of the unimproved switchgrass cultivar ,'Alamo', the Ceres ,'EG 1101' improved ,'Alamo' variety, and the Ceres ,'EG 1102' improved, 'Kanlow' variety. Second-year establishment was high for all varieties in all locations. Plant biometric traits differed significantly among varieties. 'Alamo' was generally characterized by a lower number of tillers, although taller and thicker than ,'EG1101' and, 'EG1102'. However, 'Alamo' and 'EG1101' were similar in number of tillers and tiller height. 'EG1102' had the highest number of tillers, lowest height, and lowest diameter. However, 'EG1102' and 'EG1101' were similar in number of tillers and tiller diameter. Interaction between variety and location accounted for the majority of variation in biometric traits. These results illustrate the importance of site suitability, as well as of local adaptation in switchgrass varieties planted as a dedicated bioenergy crop in east Tennessee. However, further studies are needed in order to evaluate switchgrass performances in mature crops. Biomass yield will be tested for correlation or association with biometric parameters as results become available.

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ECONOMICS OF RESIDUE HARVEST: REGIONAL PARTNERSHIP EVALUATION

David W. Archer[a], David J. Muth[b], Jacob J. Jacobson[b], Douglas L. Karlen[c]

Economic analyses on the viability of corn (Zea mays, L.) stover harvest for bioenergy production have largely been based on simulation modeling. While some studies have utilized field research data, most field-based analyses have included a limited number of sites and a narrow geographic distribution. An Iowa case study is developed illustrating the use of data extracted from a database of geographically distributed field studies for a region-specific economic analysis. The analysis utilizes grain and residue yield and associated management information from two Iowa field research sites that are Sun Grant Regional Partnership locations associated with the Corn Stover Regional Partnership Team and the Renewable Energy Assessment Project (REAP). This information is used with the Biomass Logistics Model, to quantify costs for delivery of corn stover to a biorefinery for three stover harvest strategies. Results show that economics tends to drive residue harvest toward higher removal rates. However, higher removal rates can degrade soil resources. Limiting harvest quantities to leave sufficient residues to protect against excessive erosion and maintain soil organic carbon levels may provide economic incentives for producers to adopt cropping practices, such as no-till and cover cropping, allowing for higher harvest rates and reducing biomass costs to the biorefinery.

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CARBON MATERIALS FROM LIGNINS WITH ENGINEERED THERMAL PROPERTIES

Darren Baker[a], David Harper[a], Joseph Bozell[a], Timothy Rials[a]

Lignin has recently received much interest for the manufacture of value-added chemicals, fuels and materials. The focus on materials has been towards the manufacture of value added products to enhance the economics of the existing pulp and emerging biorefinery industries. Most recent research has been directed towards the use of commercial lignins in the manufacture of carbon fiber and carbon nanofibers, and also in resins where the lignin is added as a replacement for one of the active components or as a low cost extender. Particular barriers to the utilization of lignin in value added products have been impurities and polydispersity of the particular lignins used. The Center for Renewable Carbon (CRC) has embarked on a program to manufacture value added lignin products from biomass and commercial lignins and has several areas of interest, which include the manufacture of carbon fiber, carbon nanofibers, lignin polymer fiber, carbon foams, graphitic materials and carbon-carbon composites. The products are expected to find applications in markets that utilize structural, insulating, conductive, separation, energy storage, filtration and light-weighting materials. The proposed proceeding will describe work towards the purification and optimization of the thermal properties of several lignins. The resulting lignins, with properties designed towards their use, will be described and examples given of their utilization in several high value products.

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CORN STOVER REMOVAL IMPACTS ON N_2O EMISSION AND SOIL RESPIRATION: LESSONS FROM AUTOMATED CHAMBER MEASUREMENTS

J. M. Baker[a], J. Fassbinder[a], T.J. Sauer[b], J.A. Lamb[c]

Corn stover removal for bioenergy production could have a variety of indirect consequences through its effect on soil processes, including N_2O production and soil respiration. Because these effects may be episodic in nature, weekly 30 minute snapshots with static chambers may not provide an accurate picture. We adapted automated soil respiration chambers by incorporating a portable N_2O analyzer, allowing us to measure both CO_2 and N_2O fluxes on an hourly basis through the growing season in a corn field in southern Minnesota in 2011 and 2012 that has been part of the Sun Grant/REAP project for the past four years, with three levels of stover removal: zero, full, and intermediate. Four chambers were installed on zero removal plots and four on full removal plots. At

the Iowa Sun Grant site, another set of automated chambers was used to monitor soil respiration in 2012 for two tillage types (chisel and no-till) and two residue removal levels (50% and no removal). Results at this site showed highest cumulative soil respiration from the no-till, 50% removal and lowest totals from the no-till, no-removal, with intermediate values for the chisel plow treatments. The MN data revealed higher N_2O emission from the full removal plots, possibly a consequence of enhanced mineralization of soil organic matter. CO_2 loss from the full removal plots was slightly lower, but the difference between treatments was much smaller than the amount of C removed in the residue, implying loss of soil carbon from the full removal plots.

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REGIONAL TESTING OF ENERGYCANE (SACCHARUM SPP) GENOTYPES AS A POTENTIAL BIOENERGY CROP

B. Baldwin[a], W. Anderson[b], J. Blumenthal[c], E.C. Brummer[d], K. Gravois[e], A.L. Halef J.R. Parish[a], L.T. Wilson[g]

Sugarcane (Saccharum spp.) has been a cash crop in the Deep South since 1795, but the area of production has been limited by its lack of cold hardiness. Energycanes, are complex hybrids derived from crosses of domestic sugarcane varieties and S. spontaneum (a cold-hardy relative). They are typically low in sugar, but high in fiber and biomass yield. The objective was to evaluate energycane hybrids for biomass yield. Replicated field trials of five genotypes (Ho 02-144 & 147; Ho 06-9001 & 9002; and Ho 72-114) were conducted across five states in the Southeast to evaluate the potential production and sustainability of energycane as a bioenergy feedstock resource. Test locations were: Tifton & Athens, GA; Starkville & Raymond, MS; St. Gabriel, LContact Information: a: and Beaumont & College Station, TX. Data collected by location years included: date of emergence, monthly height and ΦBrix, and end of season biomass yield. After two full year's growth, data indicated greatest plant height was observed during mid to late September at all locations. Termination of growth corresponded to a decrease in soil temperature below 30 C. Brix varied with location and genotype, but maximum ΦBrix was observed in mid-October. A genotype by location interaction was also observed for yield. Generally, clones that did the best at southern most locations had lower biomass yields at the northern most locations. Yields in the first full year of production ranged from 8.72 Mg/ha (Ho02-144 @ Raymond, MS) to 57.04 Mg/ha (Ho 06-9001 @ Beaumont, TX). Record cold weather did impact yield, but no clones were lost.

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ECONOMIC COMPETITIVENESS OF ETHANOL PRODUCTION FROM CELLULOSIC FEEDSTOCK IN TENNESSEE

Ankit Bansal[a], Prabodh Illukpitiya[a], Surendra P. Singh[a], FissehaTegegne[a]

Transformation of the renewable and abundant biomass resources into a cost competitive, high performance biofuel can reduce Tennessee's dependence on fossil fuel and enhance energy security. This study evaluates the economic feasibility of selected bioenergy crops for Tennessee and compares their cost competitiveness. The selected lignocellulosic feedstock consists of switchgrass and Miscanthus. Financial analysis was used to select feasible feedstock for biofuel production. For each feedstock, net return, feedstock cost per Btu, feedstock cost per gallon of ethanol, breakeven price of feedstock and breakeven price of ethanol were calculated. The analysis focused feedstock for biofuel production over 25 year project period. Preliminary research shows positive annual equivalent net returns from ethanol production form both feedstock. Sensitivity analysis showed that the feedstock cost for a gallon of ethanol and the breakeven price of ethanol from switchgrass and miscanthus were within a promising range. The results generated here are preliminary and should interpret with caution.

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QTL FOR BIOMASS YIELD AND COMPOSITION IN ENERGY SORGHUM (SORGHUM BICOLOR L. MOENCH)

Matthew S. Bartek[a], Seth C. Murray[a], Patricia E. Klein[b], John E. Mullet[b], William L. Rooney[a]

In the past several years, QTL studies of sorghum have identified genomic regions that influence both biomass yield and composition. Most of these studies also conclude that these traits are strongly influenced by plant maturity and height. While loci controlling height and maturity could be considered as biomass QTL, the presence of variation for these two traits biases the detection and effect of other QTL for biomass yield and composition. The objective of this study was to conduct QTL analysis in a population of bioenergy sorghum that does not segregate for maturity and height. One hundred F4:5 recombinant inbred lines derived from the cross of two photoperiod sensitive, tall sorghum genotypes (R07018 / R07020) were evaluated in two long day environments for

biomass yield and composition. Phenotypic and genotypic variation was identified in the RIL. QTL analyses of each environment identified many QTL for both biomass and composition. As expected, preliminary QTL analyses indicates that some QTL are detected across environments while others are unique to a subset of environment(s). Our study confirms that yield and composition QTL can be identified in populations in which major maturity genes are not a contributing factor and that evaluation in these populations is important to elucidate the genetic basis of biomass yield and composition in energy sorghum.

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MECHANISTIC MODEL DEVELOPMENT OF FUNDAMENTAL BIOLOGICAL AND PHYSIOLOGICAL PROCESSES GOVERNING LIPID PRODUCTION BY MICROALGAE

Barbara C. Benson[a], Carlos J. Fernandez[b], Joe M. Fox[c]

Microalgae biomass production efficiency depends on optimization of various fundamental processes, such as interception of photosynthetic photon flux density (PPFD), CO_2 uptake through photosynthesis, and biomass production and partitioning into primary organic fractions such as carbohydrates, proteins, and lipids. Quantification of these fundamental processes is essential to optimize microalgae production. Mathematical expressions of the various biological and physiological processes governing microalgae production and their responses to environmental factors are being integrated into a mechanistic model to gain a fundamental understanding of their complex interactions and to optimize the efficiency of microalgae production.

The conceptual components of model development and the quantification of fundamental biological and physiological processes governing lipid production by microalgae will be discussed. These numerical relationships include a complex network of equations. PPFD (how it is attenuated by the aqueous medium and how this relationship is influenced by the availability of PPFD at the culture surface, the depth or thickness of the culture, and the density of the biomass) is the forcing function of the mass balance model. The biomass density is determined by the specific growth rate, which is driven by the PPFD that hits cells within the culture. This latter relationship is influenced by the mixing rate (cell light/dark cycling by self-shading), the dilution rate, and the intrinsic reproductive capacity of the microalgae (partially rhythmic and partially stochastic in nature). Stoichiometry used to quantify carbon assimilation into biomass and biomass partitioning into primary organic fractions such as carbohydrates, proteins, and lipids.

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CURRENT LIFECYCLE ANALYSIS METHODS ARE INADEQUATE FOR EVALUATING CLIMATE MITIGATION OPTIONS

Richard Klotz[a], Antonio M. Bento[a]

Lifecycle analysis (LCA) estimates of greenhouse gas emissions savings are frequently used to establish whether technologies reduce greenhouse gas emissions. In programs such as the US Renewable Fuel Standard and the EU's Renewable Energy Directive, policy makers are increasingly using LCA emissions savings metrics to establish which technologies warrant support from technology-based climate policies. Our concerns are that current widely accepted attributional and consequential LCA methods are not designed to measure the impact on emissions of a policy induced change in a technology and do not simultaneously account for the complete set of market adjustments resulting from a policy intervention. We propose a novel policy-based method for calculating lifecycle emissions savings that addresses these concerns. We demonstrate the superiority of our method relative to current LCA methods in the context of US biofuel policy. We find that technology specific LCA methods routinely generate inaccurate estimates of the predicted impact of biofuel policies on emissions. The policy-based estimates of lifecycle emissions savings vary tremendously across policies, from -36.6 gCO_2e/MJ to 8.6 gCO_2e/ MJ. Depending on the policy considered, attributional LCA estimates emissions savings that range from 4.8 times the emissions savings to 1.9 times the emissions increases estimated with the policy-based method. Likewise, emissions savings estimated with consequential LCA range from 0.7 times the emissions savings to 0.7 times the emissions increases estimated with the policy-based method. Our results suggest that for policy evaluation, current attributional and consequential LCA methods should be avoided or used with caution.

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FARMERS' WILLINGNESS TO PRODUCE ALTERNATIVE CELLULOSIC BIOFUEL FEEDSTOCKS IN KANSAS USING STATED CHOICE EXPERIMENTS

Jason S. Bergtold[a], Jason Fewell[b], Jeffrey Williams[c]

Many studies have assessed the technical feasibility of producing bioenergy crops on agricultural lands. However, while it is possible to produce large quantities of agricultural biomass for bioenergy from lignocellulosic feedstocks, very few of these studies have

assessed farmers' willingness to produce these crops under different contracting arrangements. The purpose of this paper is to examine farmers' willingness to produce alternative cellulosic biofuel feedstocks under different contractual, market, and harvesting arrangements. This is accomplished by using enumerated field surveys in Kansas with stated choice experiments eliciting farmers' willingness to produce corn stover, sweet sorghum and switch grass under different contractual conditions. Using a random utility framework to model the farmers' decisions, the paper examines the contractual attributes most likely to increase the likelihood of feedstock enterprise adoption. Results indicate that net returns above the next best alternative use of the land, contract length, cost-share, financial incentives, insurance, and custom harvest options are all important contract attributes. Farmers' willingness to adopt and their willingness-to-pay for alternative contract attributes vary by region.

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THE SUNGRANT POPLAR WOODY CROPS RESEARCH PROGRAM: ACCOMPLISHMENTS AND IMPLICATIONS

William E. Berguson[a] , Bernard McMahon[a], Brian Stanton[b], Rich Shuren[b], Raymond Miller[c], Randall Rousseau[d], Michael Cunningham[e], Jeff Wright[e]

Members of the genus Populus are considered some of the most promising taxa for use as woody energy crops due to their rapid growth, ease of propagation, repeated multiple harvests through coppicing, desirable raw material properties and potential for genetic improvement through inter-specific hybridization followed by clone selection. The aim of the Sungrant Poplar Feedstocks Team is to increase yield and genetic diversity of poplar for use as an energy crop. To that end, a total of 93 research sites are actively measured in a large national field study network. This includes sites that pre-date the DOE/Sun Grant program and those established since the program began. Data are collected from clonal trials, yield tests, spacing trials, and large-scale genetics tests with some locations containing over 900 genotypes. Information is reported on progress in breeding, field testing of new genotypes and yield analyses in the various regions of the United States.

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SUSTAINABLE CORN STOVER HARVEST FOR CELLULOSIC ETHANOL

Stuart J. Birrel[a], Douglas L. Karlen[b], Nathan Schock[c]

The U.S. EPA identified corn stover as "the most economical agricultural feedstock … to meet the 16 billion gallon cellulosic biofuel requirement." They estimated that 7.8 billion gallons of ethanol would come from 82 million tons of corn stover by 2022. POET-DSM Advanced Biofuels is constructing a commercial scale plant near Emmetsburg, IA and expects to begin producing cellulosic ethanol from corn stover in 2013. For the past several years, POETDSM has been working with farmers, researchers and equipment dealers on harvest, transportation and storage logistics of corn stover. To monitor the impact of stover harvest on soil productivity, a multi-year cooperative research project was developed with USDA-ARS and ISU researchers. A field study was conducted on a 50 ha (125 acre) Clarion-Nicollet-Webster site using seven stover management treatments including no removal, cobs only, and harvest of approximately 50 or 90% of the above-ground biomass. The quantity of stover harvested, subsequent grain yields and soil-test results for the first four years will be presented. Although there were no statistically significant differences among the seven treatments, there are preliminary indications that tillage intensity should be reduced and/or the grain yields increased to ensure long-term sustainability of the various harvest strategies. Lessons learned from two commercial-scale corn stover harvests will be discussed and compared to results from Sun Grant Regional Partnership Corn Stover Team studies to show how plot-scale and on-farm research information can be scaled up for viable, commercial cellulosic bioenergy ventures.

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QUANTITATIVE GENETIC ANALYSIS OF BIOMASS YIELD, PEST RESISTANCE, AND OTHER AGRONOMIC TRAITS IN PRAIRIE CORDGRASS AND CUP PLANT

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Prairie cordgrass (Spartina pectinata), and cup plant (Silphium perfoliatum) are currently being evaluated for biomass feedstock production on marginal lands in the northern Great Plains and Midwest. Half-sib families of these species were evaluated in replicated single-row plots at Brookings, SD and Madison, WI in 2010 and 2011 for biomass production and several other agronomic traits. Significant differences were found among families of prairie cordgrass in SD and among families of cup plant in WI. Estimates

of narrow sense heritability for biomass were generally moderately high, indicating ample additive genetic variation to achieve progress from selection. No genetic variation was found for resistance to the giant eucosma (Eucosma giganteana) in a population of cup plant evaluated in SD. It is expected that this research will identify superior families and perhaps superior individuals within families that will result in the development of new high-biomassyielding cultivars of each species. Finding pest resistance will require screening of more germplasm.

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EFFECT OF MECHANICAL CONDITIONING ON THIN-LAYER DRYING OF ENERGY SORGHUM (SORGHUM BICOLOR (L.) MOENCH)

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Cellulosic energy varieties of Sorghum bicolor (L.) Moench show promise as a bioenergy feedstock, however, high moisture content at the time of harvest results in unacceptable levels of degradation when stored in aerobic conditions. To safely store sorghum biomass for extended periods in baled format, the material must be dried to inhibit microbial growth. One possible solution is allowing the material to dry under natural in-field conditions. This study examines the differences in thin-layer drying rates of intact and conditioned sorghum under laboratory-controlled temperatures and relative humidity levels (20¬∞C and 30¬∞C from 40% to 85% relative humidity), and models experimental data using the Page‚Äôs Modified equation. The results demonstrate that conditioning drastically accelerates drying times. Relative humidity had a large impact on the time required to reach a safe storage moisture content for intact material (approximately 200 hours at 30¬∞C and 40% relative humidity and 400 hours at 30¬∞C and 70% relative humidity), but little to no impact on the thin-layer drying times of conditioned material (approximately 50 hours for all humidity levels < 70% at 30¬∞C). The drying equation parameters were influenced by temperature, relative humidity, initial moisture content, and material damage, allowing drying curves to be empirically predicted. The results of this study provide valuable information applicable to the agricultural community and to future research on drying simulation and management of energy sorghum.

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INTEGRATING SEPARATION AND CONVERSION – CONVERSION OF BIOREFINERY PROCESS STREAMS TO BIOBASED CHEMICALS AND FUELS

Joseph J. Bozell, Anton Astner, Darren Baker, Diana Cedeno, Thomas Elder, Omid Hosseinaei, Lukas Delbeck, Jae-Woo Kim, C. J. O’Lenick, Timothy Young

The concept of the integrated biorefinery is critical to developing a robust biorefining industry in the United States. Within this model, the biorefinery will produce fuel as a high volume output addressing domestic energy needs, and biobased chemical products as a high value output providing necessary economic support for fuel production. This paper will overview recent developments within two aspects of integrated biorefinery development - the fractionation of biomass into individual process streams and the subsequent conversion of these process streams into chemical products. Solvent based separation of switchgrass, poplar and mixed feedstocks is being developed as a biorefinery “front end” and will be described as a function of fractionation conditions. Control over the properties and structure of the individual biomass components (carbohydrates and lignin) can be observed by adjusting the fractionation process. Subsequent conversion of the process streams from this fractionation leads to low molecular weight aromatics and potentially, drop-in hydrocarbon fuels from the selective chemical and biochemical oxidation of lignin. Alternatively, the carbohydrate stream will provide building blocks for production of new nanostructural materials, serving as templates for catalyst support and delivery.

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SOLVENT SYSTEMS FOR ENHANCED FURFURAL AND HYDROXYMETHYLFURFURAL PRODUCTION FROM CELLULOSIC BIOMASS

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Cellulosic biomass derived reactive intermediates (RIs) such as furfural and hydroxymethylfurfural (HMF) and levulinic acid are potential building blocks for sustainable production of drop-in hydrocarbons such as jet fuel. Currently, limited process yields hinder their competitiveness as a fuel precursor. However, significant yield improvements are possible by using organic solvents like tetrahydrofuran (THF) and methyl isobutyl ketone (MIBK). MIBK is an effective extracting solvent in a biphasic reaction and THF’s miscibility in water allows for both a single phase and biphasic reaction. Although literature is abundant on the production of these RIs from pure sugars, information on solvent system performance with cellulosic biomass is limited. In this study, we confirm the

capability of these solvents to enhance RI production from raw maple wood and assess their feasibility for an industrial process. The major C6-sugar product was HMF for a biphasic solvent reaction and levulinic acid for a single phase solvent reaction. The major C5- sugar product for all reactions was furfural. Furthermore, both solvents demonstrated a high affinity to furfural – MIBK achieved 95% extraction efficiency with furfural and THF improved the solubility of furfural in water by more than double.

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USING DAYCENT TO MODEL THE SOIL IMPACTS OF HARVESTING CORN STOVER FOR BIOENERGY

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Minimizing GHG emissions and avoiding soil carbon (C) depletion associated with feedstock production is a key concern with the development of corn stover for biofuel, in order to prevent reductions in soil fertility and negative climate impacts from residue removal. While experimental data are crucial to understand site-specific corn stover removal impacts on soil C and GHG flux, models are needed to project how corn stover removal may impact the land on greater temporal and spatial scales. We used grain yield, soil C, and N_2O flux data collected from published literature as well as multiple Corn Stover Removal Team experimental sites to test DAYCENT performance modeling the impacts of corn stover removal. We aggregated measured data across residue removal treatments and compared measured trends to DAYCENT modeled results. DAYCENT performed well simulating SOC change, reasonably well simulating average grain yields, but represented interannual grain yield poorly. In this analysis, residue removal did not significantly affect average soil C change or yields. DAYCENT underestimated N_2O flux, which is an area for further model parameterization to better predict impacts of residue removal on GHG flux.

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DISTRIBUTION OF ENERGY CONTENT IN CORN PLANTS AS INFLUENCED BY CORN RESIDUE MANAGEMENT

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Economic, environmental, climate change and energy independence issues are contributing to rising fossil fuel prices and creating a growing interest in the development and utilization of biomass feedstocks for renewable energy. Potential feedstocks include perennial grasses, timber, and annual grain crops with a current focus being placed on corn (Zea mays L.) stover. As part of the Sun Grant Regional Partnership corn stover project, a field study incorporating stover removal management practices was initiated in 2008 on plots composed of Coxville/Rains-Goldsboro-Lynchburg soil associations in South Carolina. In addition to annual yield and soil quality responses being reported elsewhere in this conference, studies were also conducted to measure any variations in the distribution of gross energy, as measured by an isoperibol calorimeter, in various corn stover fractions — whole plant, bottoms, tops, and cob (n = 20). Cobs were found to be the most energy dense with an average value of 18.54 MJ/kg-db. The top half of the corn plant, considered to be the biomass above the ear shank , was more energy dense than the bottom half — 18.42 vs. 18.06 MJ/kg-db. Gross energy content of the whole plant, including the cob, was determined to be 18.62 MJ/kg-db. Over the four years, partial to total removal (i.e., 25 to 100%) of the above-ground plant biomass was dependent on rainfall and could supply between 30.3 and 162.1 GJ/ ha. At 162.1 GJ/ha, the quantity of corn stover biomass (whole plant) available in a 3254 km2 area (32 km radius) could potentially support a 500 MW power plant.

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INCORPORATING UNCERTAINTY INTO LIFE-CYCLE ANALYSIS (LCA) OF SHORT-ROTATION WILLOW (SALIX SPP.) CROPS

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Life-cycle analysis (LCA) methodologies are popular tools for quantifying the energy demand, materials usage, and environmental emissions of biofuels over their entire life cycle. In order to estimate fossil fuel demand and greenhouse gas emissions associated with short-rotation willow (Salix spp.) crops in New York State, we constructed an LCA model capable of estimating point estimates

and measures of variability for a number of key processes across 8 management scenarios. Our analysis identified a small number of variables driving the performance of the entire system. The largest fraction of the energy demand across all scenarios was driven by the use of diesel fuels, the largest proportion of which was associated with final harvesting and delivery of willow chips. Similar patterns were found for greenhouse gas emissions across all scenarios, as fossil fuel use served as the biggest source of emissions in the system. Carbon sequestration in the belowground portion of the willow system provided a large carbon sink that more than compensated for carbon emissions across 8 scenarios. The subsequent uncertainty analyses revealed that variability associated with willow yield, leaf decay, and belowground carbon sequestration resulted in large variability in system-wide performance. Standard deviations for both energy demand and greenhouse gas emissions overlapped widely across all scenarios. We conclude from this analysis that a better understanding of what drives variability in the biological portions of the system is necessary to produce reliable estimates of the emissions and energy performance of short-rotation woody crops.

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PRODUCTION SYSTEM OF SUGAR CANE IN SÃO PAULO STATE – BRAZIL: A CONCEPTUAL MODEL

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The production of sugar cane in Brazil started only 25 years after its discovery in 1500 and is currently one of the main agricultural crops of the country. The sugar cane stands for one of the oldest cultures in Brazil, presently, the cultivation of sugar cane is the third largest planted area in Brazil, mainly because it represents an alternative and renewable source of energy. The most prominent producing region is the South-Central-Southeast with more than 85% of production and the largest national producer is the State of São Paulo with approximately 60% of this production. The production system of sugar cane is complex: the production plants depend on sugarcane growers and capital goods. The products alcohol, sugar and energy are distributed to fuel and electricity distributors, food industry, wholesale and retail, trading and exporting. The environmental and social equity concerns have been strengthened in recent years, especially due to market globalization. As a result of the society awareness that has emerged from the new global posture, the need arises for adjustment of agricultural activities or agro-industrial processes for the entire production system to generate positive impact for the environment and society. This article aims to show the information raised and organized about the of system production sugarcane in the São Paulo State and from that create a proposal of conceptual model of this system. This model will be validated by experts of Sugar Cane Sustainability Area. This work can be the basis for future sustainability assessment of the production of sugar cane.

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STUDYING THE EFFECTS ON WOODY BIOMASS PRODUCTIVITY OF GENOTYPE-BY-ENVIRONMENT INTERACTIONS

John E. Carlson[a,b], Joshua R. Herr[a], Armen Kemanian[c], Stephen DiFazio[d], Timothy Volk[e], Michael Jacobson[a], Raymond O. Miller[f], Lawrence Smart[g]

There is great potential for the production and use of short rotation woody biomass for the sustainable production of biofuels, bioenergy and bioproducts in the US. The growth of perennial woody crops, such as shrub willow (Salix spp.), as a bioenergy feedstock offers significant advantages with respect to net energy ratio, soil conservation, nutrient management, biodiversity, and sustainable utilization of marginal agricultural land unsuitable for food crops. The deployment of perennial willow crops on marginal lands faces significant barriers, however, one of which is a lack of understanding of cultivar by site interactions that are essential for yield modeling. The NE Sun Grant Project NE 11-48 “Genetic Improvement for Yield and Establishment of Short Rotation Woody Biomass Crops on Marginal Lands” is taking a multiinstitutional, multi-disciplinary approach to increase yields of shrub willow through genomics, breeding, and improving agronomic techniques. Survival and production data are being collected from a network of new and existing trials of willow clones across 10 states, including stem diameters, stem number, leaf area index, foliar nutrient concentrations, stem height, light use efficiency, stem biomass weight and composition, and site environmental characteristics. Climatic data is being compiled and soil samples analyzed, including elemental analysis and metagenomics (total soil DNA sequencing). Correlations of production, climatic and soil composition data with variety yields and stress responses will allow the development of a predictive model that will allow growers and extension educators to identify varieties that have the greatest yield potential for a particular site.

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SYNTHESIS OF FLUOROGENIC MODEL COMPOUNDS FOR BIOPROSPECTING OF ENZYMES THAT BREAK LIGNIN-HEMICELLULOSE BONDS

Cheng-Wei Tom Chang[a], Qian Zhang[a], Nancy Kravit[b]

Separating polysaccharides in wood from lignin is the major difficulty in using forest biomass. The problem is mostly due to ether bonds between lignin and hemicellulose, especially the - or - benzyl and phenolic ether bonds. Using an enzyme pretreatment instead of current high stringency chemical procedures is much more environmentally friendly. We have designed and synthesized fluorogenic probes mimicking the structure of lignin-mannan ether bonds. These probes will be assayed for bond hydrolysis, and bioprospected for microbes capable of specifically breaking lignin-mannan ether bonds. We expect to elucidate the synthetic pathways to models of non-glycosidic ether bonds between lignin and hemicellulose. Enzyme activities from 3-5 potential sources can then be tested for their ability to specifically cleave those lignin-mannan ether bonds. The outcomes will increase the efficiency in biofuel production from lignin-hemicellulose based biomass and increase environmental friendliness of biorefineries.

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NITROGEN APPLICATION AND HARVEST TIMING AFFECT BIOMASS YIELD AND COMPOSITION ON CRP GRASSLAND

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Conservative Reservation Program (CRP) grassland has potential to be used for biomass feedstock production. However, management strategies for soil fertility and harvest timing are needed for sustainable production. A replicated study was conducted from 2009-2011 to investigate the biomass yields and compositions of CRP grassland with mixed alfalfa and grass vegetation in central Montana, as affected by nitrogen (N) application rates and harvest timing. Nitrogen was applied in the spring of each year at 0, 56, and 112 kg N/ha and biomass was harvested at peak production and after frost kill. Biomass yields varied from year to year. Nitrogen and harvest timing had significant effects on biomass yields. Averaged over three years, biomass yields were 3479, 3762, and 3998 kg/ha at 0, 56, and 112 kg/ha N rates, respectively. The biomass yield was 4105 kg/ha at the peak production stage, compared with 3387 kg/ha at the frost kill. Nitrogen application and harvest timing also significantly affected the species compositions. The proportion of alfalfa significantly decreased from 49% to 35% and the grass significantly increased from 51% to 65% when the N rate increased from 0 to 56 kg/ha, and the species compositions did not change when N rate further increased from 56 to 112 kg/ha. At the peak production stage, the proportion of alfalfa and grass was 52% and 48%, respectively, compared to 29% and 71% at frost kill. Less alfalfa proportion in the biomass at frost kill was due to the senescence and drop of alfalfa leaves.

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INVESTIGATING THE VIABILITY OF CAMELINA SATIVA AS AN ENERGY CROP IN CENTRAL MONTANA

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Camelina sativa has been identified as an oilseed bioenergy feedstock, but a sustainable production for this energy crop has not yet been well developed. Moreover, there is a major concern about bioenergy feedstock production directly competing for land use with food crops. One potential resolution is using camelina as a rotation crop to grow in traditional fallow periods in wheat-based production systems, resulting in a complementarity, rather than substitution, to food crops. This study investigates the impact of using camelina as a rotation crop on winter wheat yields and system profitability. A replicated rotation study with each crop appearing in each year was conducted from 2008 to 2011, and the performance of the camelina-winter wheat rotation was compared to fallow-winter wheat, barley-winter wheat, and canola-winter wheat rotations. Average winter wheat yields were 2401, 2331, and 1858 kg/ha following camelina, canola, and barley, respectively, representing a 13.2%, 15.7% and 32.8% winter wheat yield reduction relative to the fallow-winter wheat rotation (2766 kg/ha). Winter wheat production decreases were offset in the cropping systems by 907 kg/ha camelina 594 kg/ha canola, and 1779 kg/ha barley. The current winter wheat-fallow rotation practice provides more net return to producers due to substantially low total cost incurred in the cropping system. To attract producers to include canola and camelina in the cropping system requires either a higher grain price and/or improving the yield potential of these crops. Although winter wheat-fallow resulted in better net return to producers, the sustainability of this practice should be evaluated with long term experiments.

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CONVERSION OF PASTURE TO ENERGY CANE FOR BIOENERGY IS PREDICTED TO ALTER GREENHOUSE GAS EXCHANGE AND SOIL CARBON

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Bioenergy related land use change stands to alter biogeochemical cycles and global greenhouse gas budgets. Energy cane (Saccharum officinarum L.) is an emerging biofuel feedstock for cellulosic bio-ethanol production with potential for high yields and limited competition with food production. The DAYCENT biogeochemical model was parameterized to infer potential yields of energy cane and how changing land from grazed pasture to energy cane would affect greenhouse gas (CO_2, CH4 and N_2O) fluxes and soil C pools. The model was used to simulate energy cane production on sandy, nutrient poor Spodosols and organic Histosols in south-central Florida. Energy cane was productive on both soil types (46-76 Mg dry mass yield); yields were maintained through three annual cropping cycles on Histosols but declined with each harvest on Spodosols. Overall, conversion from pasture to energy cane created a sink for GHGs on Spodosols and reduced the size of the GHG source on Histosols. However, the change from pasture to energy cane caused Histosols to lose 4493 gCO_2 eq . m-2 over 15 years of energy cane production. Cultivation of energy cane on former pasture on Spodosol soils in the southeast US has the potential for high biomass yield, GHG sequestration, and at these yields could spare significant areas of land in meeting the US cellulosic ethanol mandate.

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ACETIC ACID INHIBITION OF LIGNOCELLULOSE-DERIVED SUGAR PLATFORM FERMENTATIONS

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Typical lignocellulose-derived sugar platforms intended for biofuel fermentations contain significant amounts of acetic acid, a documented inhibitor of yeast growth. One approach to circumventing the negative effects of acetic acid in these sugar platforms is to make use of microbial strains that are themselves tolerant of elevated levels of such acids. This study addressed this approach by evaluating a yeast (S. cerevisiae) library of deletion mutants for acetic acid-resistant isolates. The genome-wide collection of mutants was screened in mixed pools for the ability to grow in standard yeast medium containing 120 mM acetic acid, pH 4.8. Survivors were plated on solid medium, confirmed by retesting, and identified by sequencing of mutant-specific oligonucleotide bar code sequences. Resistant mutants were then subjected to quantitative dose-response analysis that related cell yield (A600 values) to acetic acid concentration. A total of 25 acetic acidresistant mutants were isolated among the 4,800 yeast deletion mutants screened. Increases in resistance ranged up to 75% relative to the parent strain based on the concentration of acetic acid that reduced cell yield twofold. Analysis of the defects shared by the mutants revealed an enrichment in mutants impaired in the processes of endocytosis, ubiquitination, and vesicle/ vacuole-mediated transport. The question of how defects in these specific processes relate to acetic acid resistance is discussed.

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POTENTIAL OF PICOCHLORUM OKLAHOMENSIS AS FEEDSTOCK FOR BIOFUEL PRODUCTION

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Algal biomass shows significant promise as feedstock for biofuel and bio-based product manufacturing. An understanding of microalgal biodiversity and performance of different species is of great importance when selecting a microalgae strain for an application. Properties such as strain cultivation requirements, biomass production rate, chemical composition and harvesting characteristics are critical for technical and economic feasibility of the algal production systems. Picochlorum oklahomensis (PO) is a microalgae strain native to Oklahoma, isolated from Salt Plains National Wildlife Refuge in Oklahoma, USA.

In this study, biomass production efficiency, downstream processing and metabolite accumulation characteristics of PO were evaluated. Chemical composition of biomass grown in Modified Artificial Seawater Medium and animal waste water were analyzed. Biomass flocculation methods, pH adjustment, biopolymer addition and electro-flocculation, were examined for algal biomass recovery from the culture medium. Oil content of the biomass produced by PO was about 20% (weight/weight, dry biomass basis). We have also demonstrated that swine lagoon waste water supports algal biomass production without additional nutrients. Adjustment of the culture medium pH to 11 was effective in flocculation of algal biomass for efficient harvest.

This study demonstrated that PO can be a viable strain for biomass production. Electro-flocculation, pH adjustment and chitosan addition were effective methods to flocculate PO cells. Further research and development work is needed to determine the economic feasibility and scalability of the flocculation techniques examined in this study.

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BEYOND THE BILLIONTON: RESOURCE ANALYSIS CHALLENGES AND OUTCOMES FROM THE REGIONAL PARTNERSHIP RESOURCE ASSESSMENT TEAMS

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The Billion-Ton Update (DOE, 2011) provides a comprehensive assessment of the potential economic availability of cellulosic feedstock resources of the US. A collaborative effort of five regional research teams conduct regionally specific analysis to support national projections. This presentation highlights ongoing research to compile historical and ongoing field trial data, improve the quantification and qualification of land availability estimates, address spatial and temporal variability in feedstock production, and identify gaps in the field of resource analysis. Utilizing outcomes from the Regional Feedstock Partnership Field Trials, we summarize the relevance and usefulness of replicated field trials of improved and novel crops to address critical issues for planning commercial scale-up of biomass for new products and energy.

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DEVELOPMENT AND DEPLOYMENT OF A SHORT ROTATION WOODY CROPS HARVESTING SYSTEM BASED ON A NEW HOLLAND FORAGE HARVESTER AND SRC WOODY CROP HEADER

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While demand for bioenergy sourced from woody biomass is projected to increase, the expansion and rapid deployment of short rotation woody crop (SRWC) systems has been constrained by high production costs and limited market acceptance of chips from first generation harvesting systems because of problems with quality and consistency. For willow and hybrid poplar SRWC systems, harvesting accounts for about 1/3 of the delivered cost. Harvesting and transport combined can account for 45-60% of delivered costs. The objective of this study is to evaluate the performance of a single pass cut and chip harvester base on a New Holland FR forage chopper with a dedicated FB130 short rotation coppice header. The project has examined the use of various in field chip collection equipment in short rotation willow and hybrid poplar biomass crops. The newly designed FB130 header can cut stems up to 10- cm in diameter and results in a superior chip quality and flow of woody biomass through the system. Median harvester speeds on gentle terrain were near 4 km hr^{-1} in mature willow crops and 10 km hr^{-1} in young poplar, which translates to harvesting rates of 0.8 and 2.6 ha hr^{-1} respectively. Harvester delays/stoppages were usually the result of ground conditions, an absence of chip collection equipment, or maintenance. The key challenge in system evolution is to optimize the operation of the harvester and chip collection equipment to minimize down time and maximize machine productivity.

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MICROBIAL CONSORTIA FOR THE SUBSTRATE SELECTIVE CONVERSION OF SUGARS AND THE REMOVAL OF INHIBITORS ACETATE AND FURFURAL

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Acetic acid, furfural, and 5-(hydroxymethyl)furfural are three inhibitors found in lignocellulosic hydrolysates. Towards our goal of developing microbial strains which do not metabolize sugars but selectively consume only the inhibitors found in these hydrolysates, we have isolated 5 strains which are able to metabolize furfural as the sole carbon source. These isolates are distinct from existing phylogenetic neighbors, and one strain (named ALS1267) phylogenetically close to Pseudomonas aeruginosa is able to metabolize 9 mM furfural in less than 9 hours. We are currently isolating the enzyme associated with the first step in the degradation pathway, furfural dehydrogenase, with the goal of expressing this protein in an E. coli that only degrades acetate.

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GASIFICATION OF SOUTHERN FOREST RESOURCES

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Southern pine and mixed hardwoods have been gasified using a pilot scale system, with varying process conditions. The unit consumes 35-70 pounds of wood chips per hours as a function of the gas flow rate. The synthesis gas, composed of carbon monoxide, carbon dioxide, hydrogen and methane has an energy content of approximately 6 MJ/m3. Gas samples have been collected for catalytic upgrading to produce synthetic gasoline and diesel.

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POTENTIAL FOR TENNESSEE TO MEET A 20% RENEWABLE TRANSPORTATION FUEL DEMAND WITH HERBACEOUS CROPS

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This paper evaluates the conditions that would be required if Tennessee is to meet a 20% renewable transportation fuel demand. The analytical tools used in this analysis include a high-resolution geospatial industrial siting model, the Biofuels Facility Location Analysis Modeling Endeavor (BioFLAME), developed by the Department of Agricultural and Resource Economics, The University of Tennessee (Wilson, 2009); and an input-output model, IMPLAN, to estimate the regional and state's economic impacts resulting from the development of mature switchgrass to energy industry. BioFLAME will be used to locate approximately 150 50-million-gallon facilities, estimates the feedstock production costs and biomass transportation distances, project land use change, and calculate the potential break even cost. This set of information will then be used to estimate the subsequent impact on the regional and state's economy. Sensitivity analysis will be is conducted to evaluate the impact of crop prices and livestock forage needs.

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CELLULOSIC BIOENERGY CROP PRODUCTION WITH MARGINAL QUALITY WATER

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In the recent years, interest in biobased fuels is increasing and the congressionally mandated goal is to use at least 36 billion gallons of biobased transportation fuels by 2022. Meeting this stated goal requires a comprehensive regional strategy that includes bringing addition area from different regions within the country under bioenergy crops. In the southwest U.S., bringing vast abandoned crop lands and areas having permeable soils under bioenergy crops can be a part of such a regional strategy. While the region has adequate supply of land, finding reliable source of water to produce bioenergy crops is the main challenge. This challenge can be met by developing marginal quality (brackish/saline) water sources for bioenergy crops production. However, information on bioenergy crops performance under elevated salinity is not well documented. This study evaluated switchgrass (Panicum virgatum L.) performance under treated urban wastewater irrigation using soil columns prepared from salt affected land over two years under greenhouse conditions. Results indicated that among the cultivars evaluated, "Alamo" was the most salt tolerant; both biomass yield and quality under treated urban wastewater were comparable to that produced under freshwater irrigation. Soil salinity increased with time under both freshwater and wastewater irrigation, however, sodicity of the soils remained below threshold level. This indicated that most of the salinity increase was due to solubilization of calcium salts, which is not expected to affect soil productivity.

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FED-BATCH, SIMULTANEOUS SACCHARIFICATION AND FERMENTATION IN A HIGH SOLIDS BIOREACTOR TO MAXIMIZE ETHANOL TITER

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The goal of this project was to evaluate fed-batch, solid-state, simultaneous saccharification and fermentation (SSF) as an approach to reduce enzyme use in converting cellulose to ethanol and maximize ethanol titer. Kraft pulp represented a fractionated cellulose feedstock. Based on the literature, average dosages of 34 FPU of cellulase (Celluclast 1.5L) and 135 CBU of ⍟ glucosidase (Novozyme 188) per gram of glucan were determined and set as 100%. Initial SSF trials were conducted in traditional submerged bioreactors, using enzyme dosages of 133% versus 67%. Kraft pulp and additional enzymes were added throughout SSF, achieving 14% final solids loading rate. Companion trials were performed where water was added instead of enzymes during substrate additions, effectively reducing net enzyme dosages to 33% and 17% of literature average. Ethanol yields were similar (77.3-83.4% of theoretical) for trials with 33-133% enzyme dosages, but fell to 36% of theoretical at 17% enzyme dosage. Net enzymes used in 33% dosage trials were 11 FPU cellulase/g glucan and 45 CBU -glucosidase/g glucan. Fed-batch saccharification and fedbatch

SSF were performed in a solid-state bioreactor, and achieved 34.8% solids loading rate. This reduced initial 133% enzyme dosage to 19%. Saccharification trials produced 103.6 g/L glucose, which was 35% of theoretical yield. This was expected, due to feedback inhibition of enzymes. SSF trials conducted with same loading pattern and enzymes dosages, however, only yielded 30.1 g/L ethanol, which represented 20% of theoretical yield. Reducing SLR to 25% increased ethanol titer to 47.1 g/L with a yield of 43.4%. Some ethanol was lost to evaporation, but low water activity inhibited yeast performance in the solid-state reactor.

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AGRONOMIC RESULTS FROM THE SORGHUM REGIONAL BIOMASS FEEDSTOCK TRIAL

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Sorghum (Sorghum bicolor L. Moench) is one of four herbaceous dedicated bioenergy crops identified by the US Department of Energy due to its high yield potential and stress tolerance. Of this group, it is the only annual crop and it is tractable to breeding and improvement. Recent breeding efforts are now producing dedicated energy sorghums. The purpose of the current study was to assess the biomass yield potential and composition of existing sorghum genotypes across different production sites in the U.S. Five sorghum hybrids and one variety were evaluated across eight locations in seven states over four years. For most agronomic and compositional traits, significant variation was detected for genotypes while the significance of environments and genotype by environment interactions depended on the particular trait. The results indicate that sorghum has excellent potential as a biomass crop and that certain environments are especially conducive to energy sorghum production.

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MODELING THE IMPACT OF ENERGY CROPS ON AGRICULTURAL SUSTAINABILITY AT THE FARM-SCALE

Gayathri Gopalakrishnan[a], M. Cristina Negri[a]

A sustainable agricultural landscape needs to balance disparate and competing objectives in order to meet environmental, economic and energy and food security goals. Pressures on the landscapes have intensified as a result of the focus on bioenergy production to mitigate greenhouse gas emissions and meet energy security demands. While some bioenergy crops such as corn may exacerbate existing environmental problems, other crops such as native grasses and woody trees could be used as tools to redesign landscapes that can be multi-functional and meet different objectives. In this study, we investigate an alternative cropping system where bioenergy crops are grown in buffers adjacent to corn such that nutrients present in runoff and leachate from the traditional row-crop are reused by the bioenergy crops (switchgrass and miscanthus) in the buffers, thus providing environmental services and meeting economic needs of farmers. The process-based biogeochemical model Denitrification-Decomposition (DNDC) was used to simulate crop yield, nitrous oxide production and nitrate concentrations in leachate for a 15 acre agricultural field in Illinois. Results from the model simulations indicated that the use of energy crops in the landscape could increase yield on lowproductivity land for corn, mitigate nitrate concentrations in the leachate by 42-85% and reduce nitrous oxide emissions by 51-95%.

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IMPROVING WOODY BIOMASS FEEDSTOCK LOGISTICS BY REDUCING ASH AND MOISTURE CONTENT

Jason B. Cutshall, W. Dale Greene, Shawn A. Baker

We compare a range of likely forest biomass harvesting systems including whole-tree chipping, clean chipping, conventional roundwood, and residue grinding to determine how each system affects woody biomass energy facilities, biomass harvesting firms, and forest landowners. Delivered costs for these systems were evaluated for a range of values for moisture content, ash content, tract size, tons of biomass removed per acre and at grinding decks, truck payload, haul distance, and diesel fuel price. Delivered cost per mmBTU decreased by over 50% for all systems as moisture content decreased from 55% to 30%. Whole tree chipping provided the lowest cost option ($4.39 per mmBTU) at ash content levels less than 1%, and unscreened grinding of clean chip residue produced the least expensive option at 5% ash ($2.87 per mmBTU). Tract size had minimal effects on any operation until

the acreage declined below 40 acres. Clean chipping and roundwood systems were considerably more expensive than whole-tree chipping operations on all tract sizes. Costs declined significantly as truck payload increased and/or haul distance decreased. Fuel price increases directly increase cut and haul costs and limit economical haul distances accordingly.

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DISEASE CONCERNS IN ENERGYCANE

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Diseases may be a limiting factor in the production of energycane, a perennial crop, by reducing annual yields and reducing the longevity of the crop cycle. Disease concerns also include the potential that a compatible pathogen could spread between energycane and sugarcane, sorghum, or corn. Widespread planting of energycane in the southeastern may provide corridor for transmission of diseases such as orange rust caused by Puccinia kuehnii throughout the entire sugarcane and energycane industries. Energycane cultivars developed at the USDA-ARS Sugarcane Research Unit are the result of crosses between clones of Saccharum spp. (primarily S. spontaneum) or near relatives and commercial sugarcane cultivars, thus energycane will likely be affected by current sugarcane diseases. Parents and progeny are screened for resistance to the major sugarcane diseases affecting U.S. sugarcane including smut cause by Sporisorium scitamineum, mosaic caused Sugarcane mosaic virus and Sorghum mosaic virus, and leaf scald caused by Xanthomonas albilineans. Parental clones have also been screened for susceptibility to ratoon stunt cause by Leifsonia xyli subsp. xyli, a disease controlled with by planting pathogenfree cuttings and preventing mechanical spread of the pathogen during harvest. Genetic variability of pathogens is another concern. For example, finding durable resistance to brown rust caused by P. melanocephala has been difficult to achieve because of the rapid development of new races of the rust pathogen. Research is also being conducted to determine the influence of different cultural practices, such as soil fertility and crop residue management, on the development and severity of diseases in energycane.

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SOUTHEASTERN REGIONAL ATLAS OF BIOMASS FEEDSTOCK POTENTIAL

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The US Southeast is well-known as a region rich in biomass potential. Combined, the nine states have been identified as the second largest contributor of potential biomass for new uses in 2030. We develop a regionally-focused, web-based atlas for policy and planning to support the expansion of existing supplies and utilization of potential biomass for energy and new products. With a scope of nine states and two territories (VA, KY, NC, SC, MS, GA, AL, TN, FL, PR and the US Virgin Islands), the tool incorporates agronomic, political, economic, and geographic data to facilitate policy to support the sustainable production of biomass for products and energy. We include individual county-level feedstock yield maps for traditional crops grown in Southeast and the nine major dedicated energy feedstocks (corn stover, energycane, miscanthus, switchgrass, hybrid poplar, cereal stover, CRP grass, sorghum and willow). Information in the database is derived from publicly available data from scientific literature, government agency data, and other reports. It also has the capability to produce composite maps by overlaying county-level feedstock maps. Socioeconomic data such as unemployment rates, farm labor, farm size, number of farms etc., together with the locations of primary feedstock field trials, biorefineries, biomass power plants and pellet producers provide quick access to information relevant to policymakers, industry planners, landowners, and resource providers.

Using feedback from regional users, the atlas shares specific answers to known questions (select specific crop, year, price, bioenergy facility type, socioeconomic data, etc.) on a regional, state and county level, depending on the information they would like to display on the map. The system is also flexible for updates as new data becomes available.

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NATIONWIDE CROP SUITABILITY MODELING OF BIOMASS FEEDSTOCKS

Michael D. Halbleib[a], Christopher Daly[a], David B. Hannaway[a]

A major objective of the Sun Grant GIS component is to gain an understanding of the spatial distribution of current and potential biofuel/bio-energy feedstock resources across the country. To this end, the Sun Grant Western Region GIS Center (PRISM Climate Group) at Oregon State University has developed, and is applying, an environmental modeling approach (PRISM-EM) for making current and potential national feedstock production maps. PRISM-EM incorporates the important environmental constraints on biomass production, namely climate and soils. This approach, rather than attempting to develop empirical models from existing biomass data, was chosen because nearly all dedicated feedstocks have insufficient information from which to extrapolate yield

nationwide. The centerpiece of the environmental model is a semimonthly FAO-style water balance simulation, which tracks precipitation input, evapotranspiration, and soil moisture depletion. An estimate of monthly relative yield (0-100 percent) is the product of the water stress coefficient and a temperature growth curve. In what is known as a "limiting factor" approach, the final relative yield is the lowest of the modeled yields resulting from the water balance simulation, plant injury curves for summer heat and winter cold, and growth constraints due to soil pH, drainage, and salinity. The crop suitability mapping system is driven by PRISM temperature and precipitation data, prepared at a monthly time step on a regular grid across the US. PRISM is a state-of-the-science climate mapping technology that produces several major spatial climate datasets for the US, including official maps for the US Department of Agriculture.

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HIGH-YIELD TROPICAL BIOMASS FOR ADVANCED BIOFUELS

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This paper describes a project to develop advanced biofuels involving a public-private collaboration of Hawaiian Commercial & Sugar Company, Hawaii BioEnergy LLC, ZeaChem Inc., the University of Hawaii, Oregon State University, Washington State University, and the Agricultural Research Service, with funding from the U.S. Departments of Agriculture, Energy and Navy. The project goals are to develop tropical feedstocks (feedstocks of strategic importance but not prevalent on the contiguous United States) for commercial biorefining; study the productivity and input efficiencies for reducing feedstock cost; analyze harvesting logistics, pretreatment and conversion technologies for these feedstocks; assess life-cycle and community impacts; and support decision-making through the development of integrated models for economic, environmental, and production sustainability.

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BIOENERGY EDUCATION AND OUTREACH THROUGH EXTENSION.ORG

Susan Hawkins[a], Jason de Koff[b], Zane Helsel[c]

The eXtension Farm Energy Community of Practice (CoP) provides an on-line environment where Land Grant University personnel and their colleagues collaborate to develop objective, researched-based outreach materials. www.eXtension.org/ag+energy hosts a wide variety of resources, from fact sheets to decision tools to multimedia, to promote a practical understanding of bioenergy issues. Topics range from feedstocks, through logistics and processing to the use of bioenergy and are targeted to the agricultural professional. Through a Sun Grant project, the eXtension Farm Energy CoP is developing an online library of multimedia resources, with an emphasis on those generated by Sun Grant investigators. Join us to see what is available for you to use – such as bioenergy curriculum, articles and webinars. Find out how to contribute your own energy resources to this eXtension archive, whether it is an image, video, research summary, case study or fact sheet.

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PROJECTING GHG EMISSIONS FROM AGRICULTURE: EFFECTS OF SHIFTING TRENDS IN CELLULOSIC FEEDSTOCK DATA

Chad Hellwinckel[a], Daniel De La Torre Ugarte[a]

Recent updates of biomass feedstock data indicate that achieving US bioenergy mandates will rely more heavily upon crop residues and forest biomass than previously thought, and less upon herbaceous grasses. Considering the changes in estimated feedstock mix, we estimate total GHG emissions from the agricultural sector will increase if ethanol mandates are met by 2025. Our earlier work projected that GHG emissions from agriculture would decline as a result of meeting mandates. Under the newest projection and using new data reported in the DOE's Billion Ton Update, emissions will increase from agriculture. New projections raise GHG emissions by 12 million metric tons carbon per year above old projections by 2030. The increase in projected GHG emissions is due to a decline in herbaceous grass plantings (which sequester soil carbon), an increase in crop residue harvesting (which inhibits soil carbon increases), and an increase in forestland harvesting (where carbon is not accounted for yet in our model, but will likely raise emissions further). If reducing GHGs from agriculture is one objective of biofuel mandates, we suggest that policies should be adopted to either incentivize herbaceous grasses over other biomass feedstocks, or restrict harvesting of crop residues and forest biomass.

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ECONOMIC FEASIBILITY OF BIOFUELS CROPS IN FLORIDA AND NEW JERSEY

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Enterprise budgets were developed, sensitivity analyses performed, and the economic feasibility evaluated for sugarcane, energycane, sweet sorghum and switchgrass for bioenergy on southern Florida's marginal lands and similarly for switchgrass grown in New Jersey. Conversion of sugarcane juice to sugar at long term average prices was similar to producing ethanol at market prices of ~$2.20/gal and profitable at average biomass yields or higher. At 2012 sugar prices (~$0.32/lb), ethanol prices needed to be greater than about $3.40/gal to compete with sugarcane for ethanol production. Breakeven costs of sweet sorghum (juice ethanol), if grown and harvested using corn silage custom practices and as the sole crop, were significantly higher than for sugarcane; but if grown as a rotation crop and handled similar to sugarcane, breakeven prices were only nominally greater than for sugarcane. Energycane and switchgrass biomass was considered for cellulosic conversion to ethanol. Breakeven prices were $0.25-0.50 higher for ethanol from energycane than sugarcane over similar yield ranges mainly because of higher processing costs for cellulosic ethanol. Switchgrass was estimated to produce results similar to the energycanes, but may have the advantage of use in livestock operations or conservation plans on marginal lands. In New Jersey when pelletizing switchgrass for direct combustion, breakeven prices were high. Utilization of direct cut harvesting (after maturity and drydown) without pelletizing offered significant cost reductions. Harvesting and handling costs were among the highest of all production practices suggesting detailed analysis of alternatives will be necessary to make these bioenergy crops profitable.

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IMPROVING BIOMASS LOGISTICS COST WITHIN AGRONOMIC SUSTAINABILITY CONSTRAINTS AND BIOMASS QUALITY TARGETS

J. Richard Hess[a], Kevin L. Kenney[a], Christopher T Wright[a], David J. Muth[a], William Smith[a]

Equipment manufacturers have made rapid improvements in biomass harvesting and handling equipment. These improvements have increased transportation and handling efficiencies due to higher biomass densities and reduced losses. Improvements in grinder efficiencies and capacity have reduced biomass grinding costs. Biomass collection efficiencies (the ratio of biomass collected to the amount available in the field) as high as 75% for crop residues and greater than 90% for perennial energy crops have also been demonstrated. However, as collection rates increase, the fraction of entrained soil in the biomass increases, and high biomass residue removal rates can violate agronomic sustainability limits. Advancements in quantifying multifactor sustainability limits to increase removal rate as guided by sustainable residue removal plans, and mitigating soil contamination through targeted removal rates based on soil type and residue type/fraction is allowing the use of new high efficiency harvesting equipment and methods. As another consideration, single pass harvesting and other technologies that improve harvesting costs cause biomass storage moisture management challenges, which challenges are further perturbed by annual variability in biomass moisture content. Monitoring, sampling, simulation, and analysis provide basis for moisture, time, and quality relationships in storage, which has allowed the development of moisture tolerant storage systems and best management processes that combine moisture content and time to accommodate baled storage of wet material based upon "shelf-life." The key to improving biomass supply logistics costs has been developing the associated agronomic sustainability and biomass quality technologies and processes that allow the implementation of equipment engineering solutions.

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EVALUATING SWITCHGRASS VARIETIES FOR BIOMASS YIELD AND QUALITY IN MASSACHUSETTS

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Currently there is little or no published data on switchgrass (Panicum virgatum L.) yield potential for Massachusetts. Our objective was to determine how cultivars perform in this northeastern United States climate and how time of harvest affected yield and quality of switchgrass. Five upland varieties (Blackwell, Carthage, Cave-in-Rock, Shawnee, and Shelter) were harvested at senescence (fall), kill frost (winter), and spring between 2009-2011. Measurements were taken for yield, ash, total nitrogen, and mineral content in the feedstock and non-structural carbohydrates in roots at each time of harvest. In the first year Carthage was the highest yielding variety, and harvesting at senescence in the fall consistently produced higher yields for all varieties than harvesting in winter or spring. Harvesting Blackwell, Cave-in-Rock, Shawnee, and Shelter as the plant went into senescence in the first year caused a reduction in yield the following year, such that winter harvests were equivalent to or better than fall and spring harvests. Nutrients such as nitrogen, phosphorus, potassium, magnesium and ash all decreased in the feedstock when the harvest was delayed from

fall to winter or spring. Soluble nonstructural carbohydrate concentrations in the roots were three times higher in the winter than in the fall. These levels decreased again in the spring. Biomass yields ranged from 6.8 Mg ha^{-1} to 12.6 Mg ha^{-1} across upland varieties in all years. Results of this study recommend a winter harvest after a killing frost rather than a fall post-anthesis harvest.

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ACCUMULATION OF BIOMASS AND COMPOSITIONAL CHANGE OVER THE GROWTH SEASON FOR SIX PHOTOPERIOD SORGHUM LINES

Leo Hoffmann Jr.[a], William L. Rooney[a]

Biomass sorghums [Sorghum bicolor (L.) Moench] are short-day photoperiod sensitive (PS) types meaning that the crop will grow vegetatively until the fall season in subtropical and temperate environments. This feature results in high biomass yield potential and mitigates drought susceptibility. The objective of this study is to assess compositional changes and biomass growth patterns over a growing season for PS sorghum. The experiment had a split-plot design with two reps, six genotypes, and 13 harvest dates. Harvest started at 60 days after planting (DAP) and continued every 15 days thereafter in both College Station (CS) and Corpus Christ (CC) in Texas, 2010. At each harvest, dry biomass yield, height and biomass composition (lignin and cellulose) were measured. The biomass accumulation followed a standard growth pattern and were maximum between 180 and 225 DAP where the best genotype produced a dry biomass yield of 24 Mg ha^{-1}. Height increased up to 400 cm between 180 and 225 DAP. Height and biomass yield patterns were similar, indicating that height is important to increase yield. Lignin and cellulose content increased with maturity with maximum lignin content between 14.5 to 15.5% and maximum cellulose at 31 to 32%; both occurred between 180 and 195 DAP at CS. The results indicate that maximum sorghum biomass accumulation occurs between 140 and 200 days and is genotype dependent. Biomass production plans for sorghum should identify different sorghum genotypes to maximize yield within these harvest times.

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NITROGEN LOSSES FROM SWITCHGRASS AS AFFECTED BY NITROGEN FERTILIZER RATE

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Little is known about nitrogen (N) losses through nitrous oxide (N_2O) emission and nitrate (NO_3) leaching as affected by N fertilization in switchgrass grown for bioenergy. Therefore, this study was conducted to evaluate how N fertilization affects N losses through N_2O emission and NO_3 leaching and the resultant N-use efficiency of switchgrass. Switchgrass was planted at Bristol, South Dakota in 2008. Three N rates (0, 56, and 112 kg N ha^{-1} applied as urea) were applied during spring from 2009 through 2011. Switchgrass was harvested during autumn each year. Biomass yield significantly increased with N application up to 56 kg N ha^{-1} but there was no benefit to 112 kg N ha^{-1}. Apparent fertilizer N recoveries were 3.8 and 5.1% at 56 and 112 kg N ha^{-1} $year^{-1}$. However, nitrogen use efficiency was higher with N fertilization at 56 kg N ha^{-1} than that at 112 kg N ha^{-1}. Cumulative N_2O emissions during the growing season increased with N fertilization. Cumulative NO_3 leaching with N fertilization at 56 kg N ha^{-1} was similar to that at 0 kg N ha^{-1}, but there was a significant increase at 112 kg N ha^{-1}. Based on the results thus far, optimum N fertilization rate in South Dakota is around 56 kg N ha^{-1}. No N application resulted in lower biomass production while a higher rate (112 kg N ha^{-1}) exacerbated adverse environmental effects.

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SITE-SPECIFIC TRADE-OFFS OF HARVESTING CEREAL RESIDUES AS BIOFUEL FEEDSTOCKS

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Cereal residues are considered an important feedstock for future biofuel production. Harvesting residues, however, could lead to serious soil degradation and impaired agroecosystem services. We evaluate trade-offs of harvesting residues including impacts on soil erosion and quality, soil organic C (SOC) and nutrient removal. Agricultural data from 369 georeferenced points on the 37-ha Washington State University Cook Agronomy Farm were used to develop straw harvest scenarios for conventional tillage (CT) and no-tillage (NT) and both two- and three-year crop rotations. Site-specific estimates of ethanol production from two- and three-year rotation scenarios ranged from 681 to 1541 L ha^{-1} yr^{-1} indicating that both crop rotation and site-specific targeting of residue harvest are important factors. Harvesting straw reduced residue C inputs by 46% and resulted in levels below that required to maintain SOC under CT. This occurred as a function of both straw harvest and low residue producing crops in rotation. Harvesting straw under CT was predicted to reduce soil quality as Soil Conditioning Indices (SCI) were negative throughout the field. In contrast, SCI's under NT were positive despite straw harvest. Replacement value of nutrients (N, P, K, S) removed in harvested winter wheat straw was

$14.54 Mg^{-1} straw. Fertilizer replacement costs of harvested winter wheat straw ranged from $36.04 to $80.30 ha^{-1} and averaged $61.04 ha^{-1} for the field. Harvesting straw involves trade-offs that will vary on a site-specific basis. Support practices such as crop rotation, reduced tillage and site-specific nutrient management need to be considered if straw harvest is to be sustainable.

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EFFECTS OF SWITCHGRASS INTERCROPPING AND BIOMASS HARVESTING ON PLANT COMMUNITIES IN INTENSIVELY MANAGED PINE STANDS

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Pine (Pinus spp.) plantations of the southeastern United States can provide biomass feedstock for biofuels via intercropping switchgrass (Panicum virgatum) and harvesting naturally-occurring understory vegetation (biobaling). Added disturbance from these practices may diversify plant communities in early rotation stands. Therefore, we evaluated plant diversity responses to these practices in pine stands established and maintained by Catchlight Energy LLC (a Chevron | Weyerhaeuser joint venture) on land owned and managed by Weyerhaeuser Company in Mississippi and Alabama during summer, 2010 and 2011. We measured vegetation coverage, lateral visual obstruction, and species composition in paired intercropped and non-intercropped pine stands (n = 25 pairs) and paired bio-baled and unharvested areas within pine stands (n = 8 pairs). We observed 269 plant species across 33 pine stands and 2 years. Switchgrass intercropping increased coverage and species richness of forbs and non-switchgrass grass species and decreased woody plant coverage. During the growing season following switchgrass establishment, lateral visual obstruction was less in intercropped stands, but by the following year, lateral visual obstruction did not differ between treatments. Bio-baling did not significantly affect vegetation communities. Intercropping may promote an initially more diverse herbaceous plant community, but longer-term studies are needed to track successional trajectories relative to switchgrass intercropping.

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GROWING MISCANTHUS FOR BIOFUELS ON MARGINAL 1 LAND AMENDED WITH 2 SEWAGE SLUDGE AND FLUE GAS DESULFURIZED (FGD) GYPSUM

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Sustainable biofeedstock production can be an eco-friendly means to supplement our growing energy 16 needs. Amending marginal land using municipal biosolids and FGD gypsum (from coal-burning power 17 plants) for growing Miscanthus giganteus was studied. An RCB design with two rates of biosolids (0 and 18 50,000 liter/ha) and 2 rates of gypsum (0 and 4 Mg/ha) in split-plot arrangement was established on 20 m 19 x 30 m replicated plots in 2010. Plant growth and bioprocessing characteristics were influenced by 20 gypsum and biosolids. The effect of biosolids on Miscanthus was more pronounced than that of gypsum. 21 Gypsum at 4 Mg/ha significantly increased the tiller numbers (11%), feedstock production (21%) and 22 glucose content (4%) over control. Biosolids at 50,000 L/ha significantly increased plant heights (29%), 23 tiller numbers (35%), feedstock production (79%), glucose (10%), and total sugar contents (3%) over 24 control. Biosolids and gypsum in combination significantly increased the plant heights by up to 31%, tiller 25 numbers up to 42%, feedstock production up to 80% (from 1 Mg/ha to 5 Mg/ha), glucose content up to 26 13%, and total sugar content up to 6%. Total carbon, nitrogen, and heavy metals concentration (Al, Pb, 27 Cu, Cd, Cr, Zn, and Ni) in Miscanthus feedstock did not vary significantly. Total and active carbon content 28 and soil quality increased when both biosolids and gypsum were applied, but CO_2 emission was slightly 29 higher with only biosolids. Our results suggest that biosolids and FGD gypsum had synergistic effects on 30 biofeedstock production and bioprocessing characteristics of Miscanthus when grown in marginal land.

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DEMONSTRATION OF ON-FARM PRODUCTION OF A DEDICATED ENERGY CROP INCORPORATING MULTIPLE VARIETIES OF SWITCHGRASS SEED

Samuel Jackson, Nicole Labbé, Paul Filson, Mark Alexander

The development of dedicated energy crops with improved yield and conversion performance is critical to sustainable bioenergy production. A demonstration scale project was developed to compare three varieties of switchgrass (Panicum virgatum L.), one standard cultivar and two improved varieties, through various production factors including feedstock genetics, management practices, harvesting equipment, and timelines in eastern Tennessee. The 809.4 ha demonstration planting included 404.7 ha of the current, commercially available, unimproved 'Alamo' switchgrass variety, 323.8 ha of the Ceres 'EG 1101' improved 'Alamo' variety, and 80.9 ha of the Ceres 'EG 1102' improved 'Kanlow' variety. The large acreages planted allowed for varietal growth

comparisons and demonstration of the entire supply chain to local farm producers. Variety trials were planted on 11 farms across 7 counties in east Tennessee. Acreages planted ranged from 10.0 ha to 44.5 ha with an average of 24.9 ha. Second year switchgrass establishment was high for all varieties. The improved variety 'EG1101' produced the most biomass by 6.4% although it was not significantly greater than 'Alamo' (P=0.05). Total 2012 dry biomass yields of 'Alamo', 'EG1101', and 'EG1102' were 58.96, 63.01, and 47.47 Mg/ha respectively. The second primary objective of the study was to analyze chemical composition, structural form, and ethanol yield of the varieties sampled. Chemical composition was analyzed by utilizing state-of-the art rapid assessment technology. Structural form and character measurements by the University of Tennessee are in progress. Partners at Ceres Inc. are conducting chemical composition analysis and DuPont Cellulosic Ethanol is conducting baseline conversion analysis.

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TRANSFORMATIVE REGIONAL APPROACHES FOR NORTHEAST WOOD ENERGY

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An important component of research on biomass feedstock production and utilization is transferring that information to stakeholders across the supply chain. To that end, a recent Sun Grant project focused on developing a variety of extension-related materials for states in the Northeast. These include: a) series of educational publications designed to be easily adapted to any state in the region, b) a "Northeast Wood Energy Webinar Series", a collection of monthly webinars focused on topics of interest and concern for the wood energy community, c) workshops and short courses where stakeholders meet to develop expertise and discuss important developments in wood energy, and d) a book entitled "Wood Based Energy in the Northern Forests", to be published by Springer in 2013. This collection of resources provides a comprehensive set of information and educational tools to assist the sustainable and effective development of wood energy in the region. Another central aspect of this effort is to develop linkages and networks. One example is the launch of a USDA regional project group entitled "NEERA 1005 - Sustainable Wood Energy", to promote cross-institutional collaboration between land grant institutions in the region. A variety of evaluation tools including focus groups, postworkshop and -webinar surveys, and interviews with university extension personnel in the region were carried out to gage needs and effectiveness of the extension materials. The degree to which the dissemination of this information has contributed to knowledge, visibility, and growth of woody biomass use in the Northeast is discussed.

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DEVELOPMENT OF AN EFFECTIVE HARDWOOD PRETREATMENT FOR THE PRODUCTION OF ETHANOL IN A REPURPOSED KRAFT MILL

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The North American pulp and paper industry is in decline due to falling demand for paper. As a result, it would be very attractive to repurpose a kraft pulp mills to the production of ethanol. The development of a pretreatment process that can be easily implemented in a repurposed kraft mill with minimum capital is described in this paper. Various pretreatments method was studied for hardwoods that would be compatible in a repurposed mill. These pretreatments method included: water autohydrolysis, and sodium carbonate, green liquor (sodium carbonate and sodium sulfide). These results show that a pretreatment based on green liquor is the most effective pretreatment for a repurposed mill. The pulps produced by this process can be enzymatically hydrolyzed to monomeric sugars with a high overall sugar recovery. The use of green liquor for pretreatment ensures that the chemicals used during pretreatment can be recovered efficiently using proven technology and can be easily implemented in a repurposed Kraft pulp mill. A patent for the green liquor pretreatment process has been applied for by N. C. State University. In addition, the use of oxygen delignification and mechanical refining can decrease the enzyme dosage to practical economical levels. Repurposing an existing kraft mill - can reduce capital investment by 70% compared to a Steam Explosion Greenfield Project, and results in a minimum ethanol revenue (MER) of $1.97/gallon of ethanol to achieve a 12% IRR. By comparison greenfield steam explosion has a MER of $2.50/gallon.

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ACCURATELY ASSESSING WOODY BIOMASS POTENTIAL IN NORTH CAROLINA, US

James Jeuck[a], Dennis Hazel[a], Robert Bardon[a]

Since 2007, NCSU Extension Forestry has conducted over 50 detailed biomass supply assessments supporting prospective projects on behalf of bio-energy industries and economic developers. These analyses leverage data from numerous sources and scales for gross woody biomass, drain, and net woody biomass distributed spatially across timberland. Described here are details of NCSU FiberAnalytics processing techniques for two levels of woody biomass supply assessment offered to clients. The first level results in state-wide, coarse-resolution, gradient maps of net supply based on client feedstock preferences. These are derived

from net supply-distance curve coefficients generated through a series of neighborhood functions performed on net supply maps. Web-hosting interactive assessment enables potential industries, policy developers or others to explore scenarios across the state. The second level of supply assessment is performed for clients with identified site locations. For each identified site, supply areas are developed for specified haul distances using road networks. All forms of potential woody biomass are applied to timberland distributed (derived from satellite imagery) throughout each supply area is summed and used to develop supply curves. Estimated demand from facility-specific demand regions for existing and potential competitors are subtracted yielding accurately portrayed net supply based on distance and feedstock type.

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INFLUENCE OF CORN STOVER HARVEST ON SOIL QUALITY ASSESSMENTS AT MULTIPLE LOCATIONS ACROSS THE U.S.

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Corn stover has been identified as a biofuel feedstock due to its abundance and a perception that the residues are unused trash material. However, corn stover and other plant residues play a role in maintaining soil quality (health) and enhancing productivity, thus use of this abundant material as feedstock must be balanced with the need to protect the vital soil resource. Plant residues provide physical protection against erosion by wind and water, contribute to soil structure, nutrient cycling, and help sustain the soil microbiota. Replicated plots were established on productive soils at several locations (IA, IN, MN, NE, PA, SD, and SC) and a multi-year study was carried out to determine the amount of corn stover that can be removed while maintaining the current level of soil quality for each soil. These sites represented a range of soil types and climatic conditions, and have been ongoing for and least five years with some much longer studies. All sites had at least three levels of stover harvest: grain only (control), maximum removal (90-100%) and a mid-range removal rate (~50%). Data from 4 sites are presented (IA, IN, MN, and NE). The Soil Management Assessment Framework (SMAF) was used to score and assess changes in selected soil quality indicators. Data shows that removal at the highest rates resulted in some loss in soil quality with respect to soil organic carbon and bulk density. These sites were converted to no-till when the experiments were initiated, thus SOC accrual because of the shift in tillage management appeared to balance any losses due to feedstock harvest. USDA Agricultural Research Service

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CORN STOVER MANAGEMENT EFFECTS ON SOIL ORGANIC CARBON CONTENTS FROM SEVERAL U.S. LOCATIONS

Jane M.F. Johnson[a], Gary E. Varvel[b], Diane E. Stott[c], Shannon Osborne[d], Jeff M Novak[e], Douglas L. Karlen[f], John A. Lamb[g], John Baker[h]

Corn stover is becoming a major bioenergy feedstock, the supply amount dependent on high quality soil. Thus, the soil resource provides the foundation for building a sustainable biofuel economy. As a bioenergy foundation, this resource must be safeguarded from overzealous residue harvest, which can exacerbate erosion and a loss of soil organic carbon (SOC). Furthermore, greater amounts of residue return may be needed on some soils and agricultural systems to maintain SOC than control erosion. Replicated plots established on productive soils were included in a multi-location (six states, 16 sites) and a multi-year study to determine the amount of corn stover needed to maintain SOC contents. A related objective assessed how management, climate and initial soil parameters influence SOC response to stover harvest. Sites in these agricultural systems represented a range of soil types, climatic conditions, and study duration. Sites had at least three levels of stover harvest: grain only (control), maximum possible residue removal and an intermediate rate. Regression analyses were used at each site to estimate the relationship between the actual amount of stover returned and the change in SOC (SOC). These sites provided SOC and corn stover data to facilitate calculation of a minimum biomass that needs to remain on the field to avoid a SOC loss. Synthesis of these results will assist refinement for stover harvest recommendations that should safeguard the soil resource and maintain future productivity.

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RECENT DISCOVERIES AND DEVELOPMENT IN THE ENTOMOLOGY OF BIOENERGY CROP PRODUCTION

Paul J. Johnson[a], Arvid Boe[a], Ken Albrecht[b], Veronica Calles Torrez[a]

Since 2004 the pest insects of switchgrass (Panicum virgatum), prairie cordgrass (Spartina pectinata), and cup plant (Silphium perfoliatum) were studied in South Dakota and Wisconsin. The switchgrass moth (Blastobasis repartella) and the switchgrass midge (Chilophaga virgati) significantly reduce tiller biomass and destroy seed production on switchgrass. The cordgrass moth (Aethes spartinana) and the cordgrass bug (Ischnodemus falicus) together can produce devastating reductions in tiller biomass and plant health of prairie cordgrass. The giant eucosma (Eucosma giganteana) reduces cup plant biomass to subeconomic harvest levels. All of these pests produce economic injury levels within three years of planting in monocultural agronomic plantings, but are negligible in natural occurrences of eachplant species. Mixed species plantings involving switchgrass, prairie cordgrass, and cup plant have highly reduced infestation rates indicating the value of predators and parasites. Mixed plantings involving cup plant also provide a viable basis for maintaining or enhancing native bee pollinator populations. By producing floral and extra-floral resources the inclusion of cup plant in mixed species plantings is attractive to bees, as well as resources for predators and parasites of pest species. Our cumulative results and interpretations support ecological community stability models where more complex combinations of plants support a greater diversity of insects and a proportionately reduced loss of plant biomass. We predict that multispecies plantings for bioenergy production could be relatively free of pesticides and intensive management.

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ENERGY BEETS AS A BIOENERGY FEEDSTOCK IN SOUTHERN GREAT PLAINS

Vijaya Gopal Kakani, Chad B. Godsey, Pradeep Wagle, Anserd J. Foster, Aparna Kakani, Raghuveer Sripathi, Arjun Pandey

Sugar feedstocks are easy to convert and efficient for biofuel production. Energy beets (Beta vulgaris L.) were not evaluated in Southern Great Plains of USA and have the potential to replicate ethanol yields of sugarcane in Brazil. The objective of this study was to evaluate energy beet for sugar and biomass yield and finally ethanol production. Five energy beet lines of BetaSeed Inc. were evaluated during 2010 and 2011 winter and 2011 summer in Stillwater, OK. Winter crop was planted on 28 Sept in 2010 and 2011 and 14 April/18 May in summer 2011. Monthly root samples were collected. Juice was extracted with commercial fruit juice extractor. Genotypes differed significantly in their root yield and year x genotype interaction was also observed. The winter 2010 and 2011 planted crop survived the winters. The final root weight for the winter 2010 and 2011 planted crop ranged between 42 and 65 wet Mg ha^{-1} and 70 and 95 wet Mg ha^{-1}, respectively. The brix was 15 to 18% and 13 to 18% for the winter crop harvested in June 2011 and 2012, respectively. Based on genotype, yield and percent brix, the theoretical ethanol yield potential ranged from 3700 to 8300 L ha^{-1} or 450 to 890 gallons ac^{-1}. Among the genotypes studies, EFC 174 produced the highest potential ethanol yields. In conclusion, energy beets can be grown during the winter and summers of Southern Great Plains in rotation with other traditional crops.

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CORN GRAIN, STOVER YIELD AND NUTRIENT REMOVAL VALIDATIONS AT REGIONAL PARTNERSHIP SITES

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Corn (Zea mays, L.) stover has been identified as a major feedstock for cellulosic bioenergy. This report summarizes grain and stover yield as well as N, P, and K removal at several Sun Grant Regional Partnership (SGRP) sites. National Agricultural Statistical Service (NASS) grain yields were used to assess the relevancy of plot-scale yields with county averages. Seasonal variation in weather patterns caused yields to differ substantially among sites and years. Nutrient removal estimates were significantly influenced by the sampling method (i.e. analysis of hand samples between physiologic maturity and grain harvest versus stover collected during the harvest operation). Based on ancillary studies that indicate corn stover should not be harvested if average grain yields are less than 175 bu ac^{-1} (11 Mg ha^{-1}), these studies show that non-irrigated SGRP sites with the highest potential for sustainable corn stover harvest were located between -91° and -93° west longitude. The more eastern (-78° w longitude) and western (-96° w longitude) sites did not have sufficient yield for sustainable routine stover harvest, although with good management, corn could still be part of an overall landscape approach for sustainable feedstock production in those areas. For producers with consistently high yields (i.e. > 200 bu ac^{-1}) and where residue management may actually be a major problem (e.g. in irrigated areas), moderate stover harvest may actually decrease fuel use and save additional energy by reducing the amount of tillage needed to prepare subsequent

seedbeds. Less intensive tillage could also preserve rhizosphere carbon and/or soil structure benefits often attributed to no-till systems.

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INITIAL WILLOW BIOMASS YIELD TRIAL RESULTS FOR MICHIGAN

Daniel Keathley[a], Raymond Miller[b], Paul Bloese[c]

Yield trials comprised of 20-26 willow clones per site were established in Michigan from 2008 to 2011 on sites ranging from south-central Michigan north through the Upper Peninsula in an effort to evaluate the potential for the development of willow as a biofuel feedstock species in Michigan. Initial results show productivity varying greatly among clones and performance rankings shifting between harvests in year 1 and year 4. Survival was also highly variable among clones within site, ranging from 10-99%. Results to date show that are some, but not many clones which are good "general performers" across this geographic region, while the performance of other clones is highly site specific, thus offering the possibility of two different strategies for the production of commercial planting stock for the region. However, it is clear that many of the better clones are those that perform well at specific sites, indicating the importance of local adaptation and broad clonal testing in the development of planting stock recommendations for willow planting stock for biofuel plantations.

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PYROLYSIS OF NORTH-AMERICAN GRASS SPECIES: EFFECT OF FEEDSTOCK COMPOSITION AND LOCATION

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Perennial grasses native to the Midwest are ideal bioenergy crops due to their potential to be productive on marginal lands. Fast pyrolysis is a simple, flexible process for converting these feedstocks into bio-oil, a precursor to liquid hydrocarbon fuels. However, organic acids and oxygenates in bio-oil lead to storage instability and limit its early adoption as a transportation fuel. Biomass constituents such as inorganic salts dramatically alter the speciation of pyrolysis products. Therefore, the objective of this study was to prospect amongst several native grasses for cultivars suitable for pyrolysis to biofuels, by investigating the effects of biomass composition on pyrolysis products. In this work, the composition of native grasses, including big bluestem, coastal panicgrass, deertongue, indiangrass, Miscanthus, sandreed, sideoats grama and switchgrass grown on four different plots was determined. Pyrolysis of the grasses was studied using analytical pyrolysis-GC/MS. The resulting pyrolysis gas contains hundreds of chemical species. Acetic acid, glycolaldehyde and acetol were major products. Potassium had a significant effect on acetic acid, acetol, levoglucosan and the biochar yield. Plot location did not have a significant effect on biomass composition or pyrolysis products.

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FEEDSTOCK OPPORTUNITIES IN THE NORTH CENTRAL REGION FOR DROP IN FUELS

Kevin D. Kephart[a], Robert J. Nelson[b]

The bio-fuels industry is well established in the North Central region of the United States. Corn-based (Zea mays L.) ethanol production has evolved since the late 1970s and biodiesel production has been underway since the mid-1990s. Companies in this region will expand or launch new facilities for commercial cellulosic ethanol production. Land-grant universities in the region have helped establish these new industries through technological developments, research on feedstocks, testing of co-products, work force development, and public education. The North Central region exhibits a range of crop productivities, including marginal lands with climates suitable for production of oilseed crops. Using existing technologies, vegetable oils, animal fats, and food wastes can be converted into green diesel and jet fuels with high energy density, very low oxygen content, and winter performance equivalent to petroleum counterparts. Development of oilseed crops that are optimized for energy or industrial uses will benefit the agricultural community by having more cropping system options to maintain or improve soil quality, while also providing disease and pest control. The region currently produces oilseed crops that are used in feed and industrial applications. Intensifying research focus on oilseed crops will significantly benefit future renewable fuel yields produced on marginal lands. The purpose of this presentation is to identify feedstocks that can be deployed in the Northern Great Plains region.

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GREEN PROCESSING: A BIOREFINERY PERSPECTIVE

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Pennisetum purpureum, Napier grass, is a naturalized perennial feedstock in Hawaii that highly resembles the former staple crop of the state, sugarcane. Because of its high moisture content, Napier grass presents a unique opportunity for separation into solid and liquid fractions via green processing. The resulting clean fibers can serve as a substrate for biofuel production, while the nutrient-rich juice can serve as a substrate or additive for microbial co-product production. Biomass age is an often overlooked parameter in biomass handling and logistics. As Napier grass matures, changes in its composition and moisture significantly affect fractionation as well as co-product and subsequent biofuel production. This study evaluated the effects of age on biochemical constituents relevant to the conversion of Napier grass into biofuel and biobased products. Samples were hand-harvested at 2, 4, and 8 months of age and passed through a cutting mill for initial size reduction. The material was then screw-pressed under 40 psi of pneumatic backpressure. The reported characteristics of solid fibers and liquid juice will have significant implications on the feasibility of biorefineries in Hawaii and other (sub)tropical regions of the world.

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SIMULTANEOUS FERMENTATION OF GLUCOSE AND XYLOSE BY CO-CULTURE IN A NOVEL BIOREACTOR

Min Hea Kim[a], Meng Liang[a], Qinghua He[b], Jin Wang[a]

The use of renewable resources, such as lignocellulosic biomasses, to produce ethanol offers great environmental and economic benefits over fossil fuel. An efficient conversion of glucose and xylose is a prerequisite for a profitable process of ethanol production from lignocellulose. Existing research has shown that, besides recombinant strategy, co-culture is a simple and promising way to co-ferment glucose and xylose for ethanol production, especially in reducing fermentation time and improving ethanol productivity. However, there is a lack of systematic study on the dynamic properties of co-culture systems. In addition, major challenges associated with xylose fermentation, such as catabolite repression on xylose uptake and low ethanol tolerance of the xylose fermenting strain, have not been fully addressed. Therefore, new approaches are needed to help understand and explore the potential of the co-culture strategy. In this work, an innovative fermentation scheme was designed, coculturing Saccharomyces cerevisiae and Scheffersomyces stipitis (formerly Pichia stipitis) in an in-house developed bioreactor for the glucose and xylose co-fermentation. With this fermentation scheme, we were able to achieve simultaneous complete consumption of glucose and xylose. In addition, the developed novel bioreactor enables us to test different fermentative conditions, such as independent oxygen transfer rate for different strains. Furthermore, the pseudo-continuous mode, i.e. continuous fermentation with cell retention, was proposed to prevent cell washout and to provide an ideal environment for cell adaptation, evidenced by the significantly improved ethanol tolerance of both strains.

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BELOWGROUND COMPETITIVE INTERACTIONS WITHIN LOBLOLLY PINE-SWITCHGRASS COCULTURE

Kurt Krapfl[a], Scott Roberts[a], Jeff Hatten[a]

This study examines the capacity for combining the long-term productivity of a commercially important timber species, loblolly pine (Pinus taeda L.), with the annual yield of a dedicated bioenergy crop such as switchgrass (Panicum virgatum L.). Growing loblolly pine and switchgrass in co-culture could be a viable means of increasing the production potential of lands throughout the southern United States. However, co-culture production systems can inherently introduce the potential for strong competitive interactions. These interactions, occurring both above and belowground, may be especially important when incorporating fast growing herbaceous species between rows of newly established pine seedlings. This study was established in 2011 to examine how competition affects soil moisture availability and foliar nitrogen content within two newly established loblolly pine-switchgrass co-culture production systems in northeastern Mississippi. Volumetric water content within soils significantly varied by treatment, distance from tree row, and sampling depth. Foliar nitrogen content of loblolly pine significantly varied by treatment at one of our sites. Similarly, switchgrass foliar nitrogen content significantly varied by treatment at one site, and approached significance at the other. Switchgrass foliar nitrogen content was also significantly greater near non-vegetated buffer zones than in alleyways. Results of this study suggest establishing non-vegetated buffer zones around tree rows of newly established loblolly pine-switchgrass co-cultures may effectively increase soil moisture and foliar nutrient availabilities.

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EFFECTS OF BIOMASS FEEDSTOCKS, GASIFIER DESIGN AND CONDITIONS ON PHYSIOCHEMICAL PROPERTIES OF BIOCHAR

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Biochar is a low-value byproduct of biomass gasification and pyrolysis with many potential applications, such as for soil amendment, synthesis of activated carbon and carbon-based catalysts. Considering the high-value applications, biochar can provide economic benefit to the biorefinery. However, the properties of biochar depend heavily on biomass feedstocks, gasifier design and operating conditions. The effects on biochar properties must be better understood so that different biochars can be made suitable for various applications. This paper summarizes the results of the physiochemical properties of biochar derived from gasification of switchgrass and forage sorghum at three equivalence ratios: 0.20, 0.25 and 0.28. The surface area results showed all biochar samples were less than 10 m^2/g. The highest volatile content was obtained at an equivalence ratio of 0.28 while the lowest was at 0.25. As expected, ash content of biochar was much higher than that of the original biomass. Biochar ash content increased with the equivalence ratio. All samples showed large peaks in FTIR spectra where the silicon band vibration occurs. FTIR spectra showed that aliphatic structure was available in biomass but not in biochar.

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ISOLATION AND CHARACTERIZATION OF LIGNIN THROUGH AN IONIC LIQUID FRACTIONATION APPROACH

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An integrated biorefinery will rely on the various components of lignocellulosic biomass to produce fuels, chemicals, and products to be economically and sustainably viable. Over the past decade, numerous pretreatment processes have been developed and optimized with the unique goal of reducing the recalcitrance of the biomass and making the cellulose fraction more accessible for biofuel production. These approaches did very little to preserve the lignin fraction of the feedstock as a potential stream for production of value-added products. An ionic liquid approach is a possible method to fractionate lignocellulosic biomass and generate a source of lignin with unique properties for the hardwood Yellow poplar (Liriodendron tulipifera). Advanced technologies such as Fourier transform infrared spectroscopy and pyrolysis-gas chromatography/mass spectrometry coupled with multivariate analysis will be used to monitor not only the changes the biomass undergoes during the ionic liquid fractionation process but also to characterize the properties of the isolated lignin.

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EFFECTS OF OUTDOOR STORAGE ON THE COMPOSITION OF SWITCHGRASS

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Biomass storage has been identified as a barrier to the development of a sustainable biomass feedstock supply chain. While there exists a developing literature on storage issues for switchgrass, its adverse effect on the composition of switchgrass for the production of biofuel have only been examined on a limited basis. The objective of this research was to evaluate the effects of alternative bale wrap and outdoor storage methods for switchgrass packaged in large round bales on the composition of biomass that potentially influence biofuel yields. Data from a bale storage experiment at Vonore, TN were used for the study. Large round bales (1.8 m [diameter] × 1.5 m [width]) harvested January 2011 were sampled for DM, stored, and sampled again for DM at 314 days (12-December-2011) to evaluate the compositional changes in stored switchgrass. The bale protection treatments were: twinewrapped without a tarp, mesh-wrapped two times without a tarp, mesh-wrapped three times without a tarp, and mesh-wrapped two times with a tarp. Results indicate that switchgrass composition varied with bale wrap method and protective cover.

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CONSERVATION RESERVE PROGRAM (CRP) GRASSLAND FOR SUSTAINABLE BIOMASS FEEDSTOCK PRODUCTION

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The 2005 Billion Ton Study proposed that up to 10 million ha of Conservation Reserve Program (CRP) grassland could be dedicated to produce approximately 110 million dry metric tons of bioenergy feedstock annually. The Biomass Regional Feedstock Partnership has identified grasslands planted under the CRP as a potential source for herbaceous bioenergy feedstock. The goal of this project is to assess the yield potential of the CRP grasslands across diverse regions and the significance of management practices on sustainable biomass production. Consistent with that goal, the objective of this project was to evaluate the biomass

production potential for CRP land dominated by either warm- or cool-season grass mixtures across the regions of national CRP land distribution during 2008–2011. Standard field-scale agricultural practices were used as management guidelines at each location. Maximum biomass yields required N fertilization; maximal yields ranged from 2.0–3.9 Mg ha^{-1} for the three warm-season CRP sites and 3.6–5.8 Mg ha^{-1} for the three cool-season CRP sites. In addition to N fertilization, precipitation during the growing season was one of the major limiting factors of biomass production. However, harvest timing did not have any consistent impact on biomass yield. In 2011, biomass production at the OK and KS sites was limited by extreme drought conditions. The results of this study demonstrated that CRP grasslands have the potential for biomass production. However, sustainable management practices, including N and harvest management, are required to maximize the biomass production.

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EVALUATING THE IMPACT OF SWITCHGRASS INTERCROPPING IN LOBLOLLY PINE PLANTATIONS ON LONG-TERM SOIL PRODUCTIVITY

Zakiya H. Leggett[a], Eric B. Sucre[a]

Switchgrass (Panicum virgatum L.) intercropping in loblolly pine (Pinus taeda L.) plantations is a novel approach to simultaneously grow biomass for biofuel production while still managing for high quality wood products. However, it is critical to understand potential effects this intensive management system could have on long-term soil productivity. As a result of this gap in scientific knowledge, a study has been established by Catchlight Energy LLC (a Chevron|Weyerhaeuser joint venture) on land owned and managed by Weyerhaeuser Company to investigate effects of intercropping and biomass management on site productivity and sustainability. The Lenoir 1 Intercropping Sustainability Study is a collaborative-based experiment with industry, university and government partners including Weyerhaeuser Company, Catchlight Energy LLC (CLE), North Carolina State University, Virginia Tech University, Duke University, Yale University, University of North Carolina-Greensboro, Roanoke College, and the U.S. Forest Service.Treatments range from pine only to pine intercropped with switchgrass with and without biomass removal. Site preparation for each treatment varied in intensity and number of entries with heavy equipment. Furthermore, treatments with switchgrass require annual entries to cut, rake, and bale this feedstock. Impacts of these nontraditional forest management approaches on soil sustainability and productivity were evaluated.

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SCREENING MICROALGAE SPECIES FOR BIODIESEL FEEDSTOCK PRODUCTION

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Thirty-four species of microalgae were screened indoors for growth rate and lipid content at water temperatures of 35 and 25° Celsius, representing predicted average local water temperatures for high and moderate temperature production periods, respectively. Specific growth rate (μ) and Non-Polar Lipid Content (LPLC) were identified as key species selection parameters for maximizing biodiesel production. A production factor (PF) combining the lipid content and highest recorded eight hour growth rate of each species was used to rank species for net lipid productivity. The top eight performers at each temperature level where tested outdoors during corresponding seasonal temperature conditions. Nannochloris sp., Dunaliella tertiolecta, Nannochloropsis oculata, and Neochloris oleoabundans were the top performers for the warm temperature runs, with production factors of 0.945, 0.990, 1.105, and 1.520, respectively.

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BIOMASS BALE COMPRESSION – INVESTIGATING THE GAIN AND LOSS

Jude Liu

Small rectangular bales of corn stover, indiangrass, switchgrass, and wheat straw were compressed to determine the energy consumption of reducing the volume by 60%. An indoor bale compressor was fabricated and used to develop mathematical models of energy and power requirements of bale compression. Commercial production of large rectangular forage bale compression was observed and energy consumption was measured; logistics was also measured. Based on these data, costs and logistics of bale compression production were analyzed. Biomass logistics system with bale compression option was analyzed. Gain and losses associated with bale compression, such as additional costs, energy balance, storage and transportation savings were systematically analyzed.

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INTEGRATING SOCIAL CAPITAL INTO BIOJET FEEDSTOCK FACILITY SITING DECISIONS

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Development of aviation biofuels (biojet) from second-generation feedstocks is gaining significant momentum from the market, production, and overall supply chain. Nowhere is this effort more significant than in the Northwest U.S. where alliances have been formed to assess the feasibility of making this goal a reality (safnw.com). To date, much effort has focused on the conversion innovations necessary for producing biojet. However, for these scientific efforts to become truly transformational for society, technologies must be compatible with regional feedstock, environmental, infrastructure, and community assets. At the local community level, siting decisions must be compatible with the existing social and cultural assets. Those assets likely include a capacity for collective action and the ability to adapt to change. Thus, siting decisions that integrate social and cultural assets into a holistic analysis of regional infrastructure and natural/ human resources may optimize site selection in multistate regional projects.

Here we describe empirical measurements for multiple core dimensions used to quantify capacity for collective action – in particular, social capital and creative vitality. These measures, when merged and analyzed via GIS techniques, are used to clarify key biojet feedstock supply chain issues present at the community level. This integrated approach will provide a better understanding of how social and cultural traits influence a community's support for or opposition to various bioeconomy issues--in this case, sustainable economic development initiatives for renewable fuels. This methodology is currently being deployed in (Idaho, Montana, Oregon, and Washington); however, the data are available to apply these concepts to other US regions.

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A NOVEL BIOMASS GRANULATION TECHNOLOGY FOR A MODERN BIOREFINERY

Sudhagar Mania, Vikram Yandapalli, and Shahab Sokhansanjb

Densification of biomass is a critical preprocessing step in the supply logistics system as it improves the bulk density, flowability and bulk storage capability of large volume of biomass. However, the current pelleting and briquetting technologies required high energy input and high cost to produce for a modern biorefinery. In this project, we have developed a novel lignocellulosic biomass granulation technology to evaluate its potential for large scale production and commercialization. Granulation is a process of agglomerating fine particles by shear/vibrating forces with or without addition of liquid binders. Granulation of lignocellulosic biomass will not only densify the biomass, but also improve the bulk flow properties of a final product at low cost. A proof of concept granulation process was developed using a lab-scale granulation unit. Wood chip and switchgrass powders were prepared to a required particle size and were granulated with two different types of binders at three different binder concentrations. A technoeconomic evaluation of granulation technology was conducted for large scale production. The granules generated from wood powders were superior in granule quality compared to switchgrass granules. The bulk flow properties and granule strengths were comparable with the biomass pellets. Economic analysis of granulation technology demonstrated that the cost of densification can be reduced up to three fold compared to pelleting technology. It was concluded that granulation based biomass densification technology can be very attractive to transport and store large volume of biomass at low cost for a modern biorefinery.

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SENSING MISCANTHUS STEM BENDING FORCE AND SWATHED BIOMASS VOLUME TO PREDICT YIELD

Sunil K. Mathanker, Alan C. Hansen, Tony E. Grift, K. C. Ting

Real time yield sensing has the potential to control the working of harvesting machinery and to generate yield maps. Miscanthus, a promising bioenergy crop, can be harvested using traditional hay and forage equipment with minor modifications. A push bar is used on harvesting machines to bend and deflect miscanthus stems prior to cutting. It is hypothesized that the force exerted by the push bar to bend the miscanthus stems is a good predictor of the biomass yield. To measure the exerted bending force, load cells were mounted on the push bar of a disk mower-conditioner. Similarly, it was hypothesized that the swathed biomass volume, formed as a result of mower-conditioner operation, is also a good predictor of the biomass yield. To measure the swathed biomass volume, a LIDAR (Light detection and ranging) sensor was used to scan the swath cross-sectional profile. The tests were conducted for three yield levels and repeated thrice. Both sensing systems were able to sense low, medium, and high yield levels. Further analysis is underway to correlate the sensed data with the yield. Further studies are needed to improve the calibration of the sensing systems,

to test the systems at varied ground speeds, and to extend the concept to other crops: corn stover, energycane, sweet sorghum, sugarcane, and willow. It is expected that the integration of developed yield sensing systems with the existing harvesting machinery would improve their work rate and reduce the biomass harvesting cost.

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DEVELOPING A LOW INPUT SWITCHGRASS FEEDSTOCK PRODUCTION SYSTEM BY HARNESSING BENEFICIAL BACTERIAL ENDOPHYTES

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Switchgrass represents a promising feedstock crop for US energy sustainability. However, its broad utilization for bioenergy requires improvement of biomass yields and stress tolerance. Our team has been working on harnessing bacterial endophytes to enhance switchgrass performance under poor growth conditions, and develop a low input and sustainable feedstock production system for marginal lands that does not compete with the production of food crops. We have demonstrated that the bacterial endophyte Burkholderia phytofirmans strain PsJN is able to colonize roots and significantly promote the growth of switchgrass cv. Alamo under in vitro, growth chamber, and greenhouse conditions. When grown under sub-optimal environmental conditions in field soil with no fertilizer application, PsJN-inoculated plants produced much higher biomass than controls, implying the potential benefit of PsJN inoculation for biomass production on marginal lands. Physiological parameter measurements showed that PsJN-inoculated Alamo had consistently lower transpiration, lower stomatal conductance, and higher water use efficiency compared with control plants. We also found that PsJN has a genotypic specific response, with no growth promotive effect on cv. Cave-in-Rock. Using switchgrass EST microarray analysis, we have conducted comparative global gene expression profiles following PsJN inoculation of both cultivars and are assembling regulatory network and specific pathways for growth promotion by PsJN. Some key candidate genes have been chosen for further function studies to elucidate the mechanisms by which endophytes promote plant growth.

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SHORT ROTATION ENERGY PLANTATION DENSITY EFFECTS ON YIELD AND RETURN ON INVESTMENT IN A FIVE-YEAR-OLD HYBRID POPLAR TRIAL IN MICHIGAN

Raymond O. Miller, Bradford A. Bender

Short rotation energy (SRE) plantations on fallow open land can be highly productive and present property owners with an opportunity to participate in developing energy markets. Diversifying the agricultural base in the Northeastern and North Central United States through the introduction of SRE plantations also has the potential to improve rural economies which have declined as forestry and agriculture production has moved away. As biomass markets develop, adoption of SRE plantation systems by growers will depend to a large extent on the returns they can obtain from their investment. This, in turn, will be highly dependent on their choice of crops and cropping system. Hybrid poplars are one promising SRE crop but the interaction between varieties (taxa) and production systems (planting density and rotation length) strongly influences costs and yields and consequently, return on investment. Fifth-year growth in a replicated study of six hybrid poplar taxa planted at three densities in Escanaba, MI was examined here. Biomass yield varied significantly among taxa and densities (ranging from 37.6 Mg/ha for NM6 at 2,200 stools/ha to 14.2 Mg/ha for DN34 at 2,700 stools/ha) and a significant interaction between treatments was observed. When yields were projected to the end of an eight-year rotation, estimated rates of return ranged from +9.6% (for NM6 planted at 1,900 stools/ha) to -4.6% (for DN34 at 2,700 stools/ha). Understanding the interaction between taxa and planting densities will be critical to the profitability of SRE plantation systems.

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HARVESTING SYSTEMS AND COSTS FOR SHORT ROTATION POPLAR

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The objective of this review is to compare the cost of coppice and longer rotation poplar harvesting technology. Harvesting technology for short rotation poplar has evolved over the years to address both coppice harvest and single-stem harvest systems. Two potential approaches for coppice harvesting are modified forage harvesters and modified mulcher-balers. Both of these systems effectively handle multi-stemmed feedstock. Total harvesting cost to roadside likely ranges from $11 to $15 Mg green. The most significant harvesting constraint with coppice systems is the requirement for dormant season operations. More conventional

poplar harvesting at production scales uses forest machines for felling and extraction. The Billion Ton Update report used previous productivity studies to estimate a roadside cost for felling and skidding of about $6 Mg green (unchipped). With chipping cost, single-stem systems are about the same roadside price as coppice harvesting. Other factors such as stand establishment, feedstock storage, and rotation length are more likely to determine an economically optimum management system.

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A CASE STUDY FOR MEETING BIOENERGY FEEDSTOCK DEMAND IN EASTERN NEBRASKA

Rob Mitchell[a], Kenneth P. Vogel[b], Dan Uden[b]

The central Great Plains and Midwest are characterized by intensive agricultural production. Maize and soybeans are commanding record prices with associated effects on land costs which are also at record highs. Although economically sustainable for maize and soybean production, the environmental sustainability of erosion prone, marginally productive cropland in the region over an extended period is questionable. Switchgrass and other perennial grasses provide an economic and environmental opportunity for these lands. In more than 20 years of research, a complete production package has been developed for the central Great Plains and Midwest. Research has demonstrated that switchgrass for bioenergy is productive, protective of the environment, and profitable for the farmer. However, switchgrass for bioenergy production has not been adopted on a large scale. Farmers do not want to plant switchgrass without a viable bioenergy market, and biorefineries do not want to build without a viable long-term feedstock supply. A land base must be available to grow the 625,000+ tons of feedstock required by a 50-million gallon per year cellulosic ethanol plant. One viable scenario is using a mixed feedstock platform including maize stover and perennial grasses. As an example, the Upper Big Blue Natural Resource District in eastern Nebraska could meet the biomass tonnage requirements of a biorefinery within a 25-mile transport distance by growing switchgrass in the corners of center pivot irrigation systems in which maize is the primary crop. Stover from the maize fields also could be used by a biorefinery.

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DISTRIBUTION OF STRUCTURAL CARBOHYDRATES IN CORN PLANTS AS INFLUENCED BY CORN RESIDUE MANAGEMENT

Spyridon Mourtzinis[a], Keri B. Cantrell[b], Francisco Arriaga[c], Jeffrey M. Novak[b], James. R. Frederick[d], Douglas L. Karlen[e]

As part of the Sun Grant Regional Partnership corn stover project, continuous corn (Zea mays L.) field studies incorporating stover removal management practices (0 and 100% removal) were established in both Alabama and South Carolina. Plots in both states were representative of major soil types in their respective region: Alabama plots were Compass and Decatur soils; South Carolina plots were composed of a Coxville/Rains-Goldsboro-Lynchburg soil association. In addition to grain and biomass yield and soil quality responses being reported elsewhere in this conference, these two sites investigated variations in the distribution of carbon and structural carbohydrates among five plant fractions: whole plant; above the first ear excluding cobs (top); below the first ear (bottom); cob; and above the first ear including cobs (above ear). Using a combination of wet chemistry methods and near infrared spectroscopy (NIRS), the distribution of carbon and structural carbohydrates varied between the sites. Stover removal was a significant factor on carbohydrate concentrations on all plant fractions and soil types except for the Decatur. When compared to the above ear fractions, bottom plant partitions revealed greater carbon, lignin and cellulose concentrations. However, holocellulose concentration was consistently greater in cobs, tops and above ear fractions at every location. Data from this study suggest that Coxville/ Rains-Goldsboro-Lynchburg soils have greater potential in producing corn biomass with desirable portions of structural carbohydrates for bioenergy, when compared to Decatur and Compass. Furthermore, the plant portions cob, top and above the first ear have the most desirable characteristics for biofuel production at all location.

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DATABASE INFRASTRUCTURE DEVELOPMENT AND MAINTENANCE FOR SUSTAINABLE PRODUCTION OF BIOMASS

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In support of advancing bioenergy feedstock research, a national collaborative framework is developed to include critical agronomic, soil, and feedstock quality characteristics of annual and perennial cropping systems. Multiinstitution and agency led trials of novel and improved crops in replicated trials contribute to an information system useful for policy, research, and education. Automated data verification and aggregation allow research to supply multi-year data via a simple workflow. Selected variables serve the

evaluation of system productivity and sustainability through data analysis and spatial visualization of plot to field-scale observations. The collaborative framework also allows for comparison to data and analysis from a various models that can lead to national scale analysis. Many data management issues from hierarchical security access to data consistency and verification were addressed during the creation of this community supported database infrastructure. This database will also support unprecedented access to plotlevel field observations as well as aggregate site data from current and historical feedstock data collected by researchers. Oak Ridge National Laboratory

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EXTENT AND DISTRIBUTION OF SUSTAINABLE INTENSIVE FOREST BIOFUEL PRACTICES

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While attempts are being made to understand effects of biofuel feedstock growth and harvesting on the environment, distribution and extent of planting is difficult to quantify. The Billion Ton Study estimated magnitude and location of possible forest sources of feedstock, but there is still much inherent uncertainty in such predictions, particularly at operational scales. Some sustainability and environmental models have included production and economic drivers to estimate land use conversion from timber to biofuel but other analyses have started with the premise of high conversion and biomass removal. To provide some estimation of distribution and extent of biofuel production in an operational forestry setting, we used an existing research platform, developed and maintained by Catchlight Energy LLC (CLE), to examine potential use of commercial forests for more intense biofuel cultivation within site limitations due to erosion potential and water quality concerns. The CLE platform is examining biodiversity, water quality and quantity, and soil productivity responses from operational intercropping of a perennial grass (Panicum virgatum) between tree rows in existing loblolly pine (Pinus taeda) plantations. Current forestry Best Management Practices were used during establishment to protect water quality and aquatic life. Early results indicate that carefully intercropped sites maintain many of the environmental benefits of a forest, but research sites also included those of marginal slope and soil stability to bound establishment conditions. Sediment monitoring, operational feedback, and logistical concerns were used to map sites suitable for biofuel operations while protecting water quality. Harvest residual measurements were added to estimate maximum biomass removal within existing pine plantations and at a landscape level. Results and methods will be presented.

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BIOTECHNOLOGICAL IMPROVEMENT OF SWITCHGRASS FOR HIGHER BIOMASS YIELD UNDER COOL GROWING CONDITIONS

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Biomass production of switchgrass (Panicum virgatum) is known to be limited by growth temperature. Under cool conditions photosynthesis is inhibited and growth reduced compared to warm conditions. In contrast, Miscanthus (Miscanthus x giganteus) photosynthesis and growth is not reduced by cool temperatures as much as that of switchgrass. Initial evidence suggests that this difference in cool temperature tolerance between these two important biomass fuel plants may be due to the action of pyruvate phosphate dikinase (PPDK). However, the mechanism of cool temperature inhibition of photosynthesis in switchgass is not well known and its relationship to PPDK is yet to be conclusively determined. Our goal was to fully understand the differences in photosynthesis that are associated with cool vs warm climatic conditions for switchgrass and Miscanthus. Following our characterization of photosynthetic and growth traits, we produced two transgenic switchgrass lines overexpressing PPDK from Miscanthus. Switchgrass plants grown under cool conditions (14C day/12C night) had reduced growth, reduced carboxylation efficiency, CO_2 saturated photosynthesis, and triosephosphate use, but no change in electron transport processes compared to warm conditions (28C day/ 25C night). Miscanthus grown under cool conditions had no significant change in carboxylation efficiency or CO_2 saturated photosynthesis. Productivity and photosynthetic parameters of the two transgenic lines were significantly less in cool conditions compared to warm. Work continues on more transgenic lines in an effort to increase cold tolerance of photosynthesis in switchgrass.

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REGIONAL PARTNERSHIP CORN STOVER MANAGEMENT EFFECTS ON SOIL AGGREGATION AND PYSICAL PROPERTIES

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Removal of corn stover as a biofuel feedstock is being considered. It is important to understand the implications of this practice when establishing removal guidelines ensuring long-term sustainability to the biofuel industry as well as ensuring we maintain

soil health. Above- and below-ground plant residue is one of the soil's main sources of organic materials that bind soil particles together into aggregates and increase soil carbon. Serving to stabilize soil particles, soil organic matter assists in supplying plant available nutrients, increases water holding capacity, and helps reduce soil erosion. Data obtained from three Corn Stover Regional Partnership sites (Brookings, SD; Morris, MN; and Lincoln, NE) will be utilized to evaluate the impact of removing corn stover on soil physical properties and aggregate stability. Field sites represent a range in soil type; climate; yield capacity and study duration. Each site consisted of three residue removal rates (low - removal of grain only; intermediate - ~50% residue removal; highmaximum amount of residue removal). Preliminary results from the Brookings, SD site showed that overall dry aggregate size distribution was less desirable in the high reside removal treatment than those treatments with greater amounts of residue remaining on the soil surface. Surface residue provides protection not only from the erosive forces of wind and water in the destruction of these smaller aggregates, but also in their creation from the breakdown of larger aggregates Incorporation of higher yielding sites as in Lincoln, NE will be included to extend this information evaluate the impact of residue removal on soil aggregation.

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SWITCHGRASS RESPONSE TO N FERTILIZER ACROSS DIVERSE ENVIRONMENTS IN THE USCONTACT INFORMATION: A: A REGIONAL FEEDSTOCK PARTNERSHIP REPORT

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The Regional Feedstock Partnership is a collaborative effort between the Sun Grant Initiative (through Land Grant Universities), the US Department of Energy, and the US Department of Agriculture. One segment of this partnership is the field-scale evaluation of switchgrass (Panicum virgatum L.) in diverse sites across the USA. Switchgrass was planted (11.2 kg PLS ha^{-1}) in replicated plots in NY, OK, SD, and VA in 2008 and in IA in 2009. Planting occurred in AL in 2010 following unsuccessful attempts in 2008 and 2009. Adapted switchgrass cultivars were selected for each location and baseline soil samples collected before planting. Nitrogen fertilizer (0, 56, and 112 kg N ha^{-1}) was applied each spring beginning the year after planting, and switchgrass was harvested once annually after senescence. Establishment, management, and harvest operations were completed using field-scale equipment. Switchgrass production ranged from 2 to 11.5 Mg ha^{-1} across locations and years. With the exception of the IA location, yields were lowest the year after planting. Yield increased with 56 kg N ha^{-1} at SD and VA but did not increase further at the high N rate. There was no effect of N at OK or IA, and a negative response at NY. Initial soil N levels were lowest in SD and VA (significant N response) and highest at the other three locations (no N response). These results demonstrate the importance of proper N management in order to reduce unnecessary expense and potential environmental impacts of switchgrass grown for bioenergy across the USA.

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STAND ESTABLISHMENT AND BIOMASS YIELD OF SWITCHGRASS IMPACTED BY SEVERAL SOILAND SEED-BORNE FUNGAL PLANT PATHOGENS

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Naturally occurring soil-borne fungal pathogens of switchgrass have been isolated and identified from growers' fields and research plots in Tennessee. These fungi are typically difficult to control because they survive in soil for long periods under unfavorable conditions, even in the absence of host plants. Several of the fungi that were isolated are known pathogens of important grain and grass crops in the southeast, such as corn, wheat, sorghum, and turfgrass. Many of these pathogens are seed-borne and play a role in stand establishment problems, causing seed rots, seedling damping-off, reduced seedling vigor, and root rots. Fungal pathogens from commercial seed and field plants were characterized and identified. Rates of fungal infection among 30 switchgrass seed lots varied from <1 to 87%. Pathogens implicated in stand establishment problems and diseases of field plants in Tennessee include the following: Alternaria alternata, Bipolaris oryzae, B. sorokiniana, B. spicifera, B. victoriae, Curvularia lunata, Fusarium acuminatum, F. equiseti, F. graminearum/ pseudograminearum, Pithomyces chartarum, and Sclerotinia homoeocarpa. Pathogenicity and virulence of several Bipolaris species were determined in experimental studies with seeds and whole plants. The impact of these isolates on stand establishment, plant health, and biomass yield was measured. Although there were significant differences in the aggressiveness of isolates, even with low disease pressure, losses in biomass ranged from <5 to 70%. These studies serve to distinguish between minor pathogens with limited impact on stand establishment and biomass yield, from those that should be targets for disease resistance in switchgrass breeding programs.

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SOIL CO_2 EFFLUXES IN SHRUB WILLOW BIOMASS CROPS ALONG A 21-YEAR CHRONOSEQUENCE AS AFFECTED BY CONTINUOUS PRODUCTION AND CROP REMOVAL (TEAR-OUT)

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Soil CO_2 efflux (Fc) is the primary pathway in the carbon (C) cycle through which the C stored in the belowground biomass is released back into the atmosphere. This study compares (a) soil CO_2 emission rates among 7, 14, 16, and 21-yr old willows and (b) between willows that were harvested and allowed to regrow (continuous production [CP]) and willows that were harvested, killed, and then ground into the soil (tear-out [TO]). Soil CO_2 emission rates, which were measured continuously for two years, showed no significant differences among the four ages ($p = 0.32$), and there was no interaction with the applied treatments ($p=0.98$). However, the mean annual soil CO_2 emission rates of CP (2.67μmol m-2 s^{-1}) were significantly higher than TO (2.22 μmol m-2 s^{-1}) ($p=0.04$). Nonzero soil CO_2 emission rates occurred year-round with highest emission during summer (July-Sept.) and lowest during winter (Jan.- Mar.). The annual cumulative soil CO_2 production ranged from 29 to 36 Mg ha^{-1} yr^{-1} for CP and 25 to 29 Mg ha^{-1} yr^{-1} for TO. Fc rates were strongly associated with soil temperature, but not with soil moisture.

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DEVELOPING LOW-INPUT, HIGH-BIOMASS, PERENNIAL CROPPING SYSTEMS FOR ADVANCED BIOFUELS IN THE INTERMOUNTAIN WEST

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Lignocellulosic biomass studies are being conducted to evaluate perennial herbaceous feedstocks and to determine their field performance and adaptation potential for biomass production in the Intermountain West. Field performance of four biomass entries and four inputs are being evaluated over a long-term testing period at three western Colorado locations. Also, a native grass field trial was planted in 2011 to evaluate new crosses of basin wildrye (Leymus cinereus) x creeping wildrye (Leymus triticoides) as potential biomass resources. The Introduced Biomass Treatment, consisting of mostly alfalfa, has consistently had the highest biomass yield at the Fruita site. In the first cutting that occurred in 2012 in the native grass species study, tall wheatgrass (Thinopyrum ponticum) and intermediate wheatgrass (Thinopyrum intermedium) had high biomass yields. An easy-to-use crop budget enterprise tool has been developed to model the economic viability of the various plant species being evaluated. There is agronomic and economic potential to develop 200-300,000 acres of marginal land within a 50-mile radius of Rifle for the production of dedicated, herbaceous biomass. A pilot plant nearing completion at the Colorado Mountain College will convert the various perennial biomass grass species into butanol. In order to advance production, further refinement of the definition of marginal lands for bioenergy crops is needed.

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BUILDING A BETTER BIOMASS ECOSYSTEM: COTTONWOOD-SWITCHGRASS AGROFORESTS ON MARGINAL LAND

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Bioenergy markets may provide revenue to landowners on marginal lands in the Lower Mississippi Alluvial Valley (LMAV) where crop returns are low due to low fertility or risk. Cottonwood and switchgrass are native to this region, grow on a wide range of soils, and produce substantial amounts of biomass. Combining these two species in agroforests will provide both annual and periodic harvests of biomass along with valuable ecosystem services such as nutrient retention and wildlife habitat. Four levels of cottonwood and switchgrass cover were established in agroforests on marginal soils at three sites in in the LMAV in Arkansas and Louisiana in the spring of 2009. In 2011 switchgrass and cottonwood growth at the most productive sites were respectively 16.2 and 4.6 oven-dry Mg/ha. Cottonwood production has doubled each growing season and could accumulate as much as 18 Mg/ha in the fourth growing season and 34 Mg/ha on a 5-year rotation. Small mammal abundance and diversity were significantly greater in switchgrass and cottonwood agroforests than in control treatments planted to a soybean-grain sorghum rotation. Nitrate concentrations in soil water in the agroforest treatments were generally lower than those in control plots. Initial results suggest that substantial biomass production from cottonwood and switchgrass can occur on marginal soils but production differs significantly among soils. Cottonwood is very sensitive to common herbicide treatments applied to rice fields. Where establishment and growth is adequate, ecosystem services are enhanced by cottonwood and switchgrass agroforests.

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COMPARISON OF THREE REMOTE SENSING METHODS TO PREDICT ABOVE GROUND PLANT BIOMASS PRODUCTION

Tucker Porter[a], Chengci Chen[b], Rick Lawrence[c], Bok Sowell[a]

A quick, accurate, and non-destructive method is needed to estimate the amount of above-ground plant biomass in a pasture or across a landscape. Direct harvesting is currently the most widely used method in determining aboveground plant biomass production. This method, however, is costly, timeconsuming, and destructive and only allows individual samples to be measured accurately out of a potentially highly variable sward. Remote sensing of vegetation spectral responses, which tend to be highly responsive to changes in biomass, promises to provide a means for frequent, non-destructive measurements of above-ground plant biomass at management relevant scales. The objective of this study was to compare different remote sensing techniques to determine which is the most accurate in predicting above-ground plant biomass production. Above-ground plant biomass production predicted by (1) the normalized difference vegetation index (NDVI) measurements collected by a ground-based sensor was compared with (2) NDVI and (3) band combination measurements collected by satellite-based imagery. Regression using a combination of near, middle, and thermal infrared bands explained the most variability (78%), followed by NDVI measured from Landsat images (8%), and NDVI measured from the ground-based sensor Crop Circle (3%). When data points containing large amounts of dormant, senesced and dead vegetation were removed, variability explained by Crop Circle improved 74% and Landsat images improved 23%.

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A TWO-STAGE CONTINUOUS FERMENTATION SYSTEM FOR CONVERSION OF SYNGAS INTO ETHANOL

Hanno Richter, Michael E. Martin, Largus T. Angenent

We established a 2-stage continuous fermentation process for production of ethanol from synthesis gas (syngas). The system consists of a 1-L continuously stirred tank reactor as a growth stage and an ethanol-production stage using a 4-L bubble column equipped with a cell recycle module. Operating conditions in both stages were optimized for the respective purpose (growth in stage 1 and alcohol formation in stage 2). The system was fed with an artificial syngas mix, mimicking the composition of syngas derived from lignocellulosic biomass (60% CO, 35% H2, and 5% CO_2). Gas recycling was used to increase the contact area and retention time of gas in the liquid phase, improving mass transfer and metabolic rates. In the alcohol production stage, C. ljungdahlii was maintained at high cell densities of up to 10 grams dry weight per liter, while continuously producing ethanol at concentrations of up to 450 mM (2.1 vol%) and ethanol production rates of up to 0.37 grams per liter per hour in stage 2. Foam control was essential to maintain reactor stability. A stoichiometric evaluation of the optimized process revealed that the recovery of carbon and hydrogen from the carbon monoxide and hydrogen provided in the ethanol produced were 28% and 74%, respectively.

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EARLY TREATMENT-RELATED COMPETITIVE EFFECTS IN A LOBLOLLY PINE – SWITCHGRASS CO-CULTURE SYSTEM

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A study examining biomass yields of switchgrass grown in co-culture with loblolly pine was established on two Upper Coastal Plain sites in Mississippi. The Pontotoc site has a history of agricultural use with some likely residual fertility, while the Starr site has a history of forest use and has been maintained for several decades as a mowed field. Treatments included switchgrass only and pine only, as well as pine planted into switchgrass with 0, 0.6, and 1.2-m competition free zones on either side of the row of pines. Second year switchgrass production differed substantially between sites, but within sites switchgrass yields per square meter of were not different. However, total switchgrass yield differed by treatments, with differences related to the width of the competition free zone around the pine seedlings. There were few treatment related differences in $year^{-1}$ tree heights at the Starr site where switchgrass yields were less than one-quarter of those at the Pontotoc site. At the Pontotoc site, mean $year^{-1}$ tree height in the pine only and 1.2-m treatment was greater than in the other treatments, averaging 18 cm taller than the 0.6-m treatment and nearly 40 cm taller than the 0-m treatment.

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DEVELOPMENT OF A BLACK WILLOW IMPROVEMENT PROGRAM FOR BIOMASS PRODUCTION IN THE LOWER MISSISSIPPI RIVER ALLUVIAL VALLEY

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Black willow (Salix nigra Marsh.) has the potential to be a significant feedstock source for bioenergy and biofuels production in the Lower Mississippi Alluvial Valley (LMAV). This potential is based on a number of primary factors including rapid growth, ease of vegetative propagation, excellent rooting, and the ability to regenerate from coppice following harvest. To date, there has been no directed black willow improvement effort for the LMAV and production rates of this species in dedicated energy plantations is unknown. The focus of this program is to identify genetically superior black willow clones and define planting stock for use in regeneration of marginal agricultural sites. Mississippi State University Forestry Department and the USDA Forest Service Center for Bottomland Hardwoods Research formed a joint venture in 2008 to pursue this effort. The initial selection strategy incorporated five geographic areas, four stands within each area, and five clones within each stand. The five geographic areas included two along the Mississippi River and one each along the Atchafalaya, Trinity, and the Brazos Rivers. From each stand five to eight one to two year-old stems were collected during the winter of 2009. Over a two-year period a total of four screening trials were established. Data from ages one and two have provided insight into geographic origin performance and heritability. These early results allowed us to design a more highly replicated clone test of the better performing clones as well as increasing selections for the base population.

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DEVELOPMENT AND DISSEMINATION OF BIOENERGY EDUCATIONAL CURRICULUM FOR CHILDREN

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It is important for the field of bioenergy that future consumers, policy makers, and taxpayers develop knowledge and awareness of bioenergy. Current resources to promote bioenergy usually target youth in grades 6-12. Research indicates that to effectively impact youth knowledge, skills, and abilities, they should be reached at earlier ages for long-term developmental outcomes. Therefore, educational resources for children are needed to increase bioenergy knowledge, appreciation, and career interest. This bioenergy curriculum for children (K-2) contributes to the national science education standards content areas of life sciences and science as inquiry. The educational material is designed to inform and educate future consumers to gain knowledge and appreciation of bioenergy. The bioenergy curriculum follows the developmentally appropriate practice guidelines for primary grades as established by the National Association for the Education of Young Children Three bioenergy curriculum pieces (each with 9-10 activities) were developed in the content areas of: 1) Bioenergy Sources (e.g., grasses & algae); 2) Bioenergy Conversion (e.g., combustion, fermentation); and 3) Bioproducts (e.g., wood, biodiesel).

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SOCIAL ACCEPTABILITY OF BIOENERGY IN THE U.S. SOUTH

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In the U.S. South, a wide range of bioenergy technologies are now in various stages of development, and a comprehensive and dynamic understanding of the social acceptability of bioenergy is critical as the bioenergy industry expands in this region. Because of the multiple values and perspectives at play across the Southern landscape, we must analyze bioenergy development broadly, taking into account diverse values, governance processes, and equity concerns. Many ideas, facts, and opinions contribute to people's perceptions of bioenergy, and conducting content analysis using a cultural models approach will enable us to understand how different people and groups see bioenergy development, how they frame the issues, where value conflicts and compatibilities lie, and how values influence behavior. In this paper, we focus on identifying key conventional discourses that people reference when they talk about bioenergy in different contexts, including public media, policy and management discussions, outreach programs, and among landowners and within communities. We hope that our research, which aims to elucidate these conventional discourses related to bioenergy, will help guide managers and policy makers by showing the beliefs and values that underlie public opinion, clarifying tradeoffs and synergies, and suggesting language-based ways to negotiate this social complexity.

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EVALUATION OF A MODULAR SYSTEM FOR LOW COST TRANSPORT AND STORAGE OF HERBACEOUS BIOMASS

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A major challenge for the developing biofuels industry is the delivery of high quality biomass feedstock at the lowest possible cost. Desirable characteristics of a biomass logistics system would be the ability to maximize the dry matter portion of total mass transported while accommodating a range of material moisture content at the time of collection, minimize the number of machines and operators in the system, rapidly load and unload maximum legal truckload quantities, provide an opportunity for distributed storage locations and minimize the total cost of conversion ready feedstocks. Logistics systems based on existing forage or silage systems have difficulty meeting some or all of these characteristics, particularly for high yielding energy crops. A conceptual system adopting features from cotton, silage and container shipping systems has been evaluated since 2009. The evaluation included both simulation of the anticipated full-scale system and field trials of forming, transporting and storing biomass modules with energy sorghum, switchgrass and corn stover. When compared to the DOE target for logistics costs of $38.59/ Mg, the estimated cost was lower for distances up to 80 km. Field results have been promising, with biomass modules of up to 5.2 Mg formed, stored for 3-12 months, loaded on a truck in two minutes or less, and transported for 96 km with no significant degradation. The manually formed modules packages were not able to maintain an anaerobic environment, and degradation occurred. It is expected that negative results for the conceptual system can be overcome with design.

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VARIATION IN BIOMASS COMPOSITION AND ENZYMATIC SACCHARIFICATION FOR BIOFUEL PRODUCTION AMONG CULTIVARS OF SHRUB WILLOW

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Variations in biomass composition based on genotypic differences or environmental influences are highly likely to have significant impact on the effectiveness of pretreatment and subsequent sugar release by enzymatic hydrolysis in the process of biochemical conversion to liquid biofuels. We have characterized extensive variation in biomass composition among willow genotypes produced by breeding and in response to site conditions. To evaluate whether the variation in composition affects conversion processes, biomass from 10 genetically diverse, high-yielding cultivars of shrub willow (Salix spp.) were pretreated with a hot-water process under two levels of severity, hydrolyzed using commercial enzyme formulations with cellulase and xylanase activities, and sugar release quantified by HPLC. Among the cultivars selected for analysis, cellulose content expressed as percent dry weight ranged from 39% to 45%, and lignin content ranged from 20% to 23%. Differences in the effectiveness of the pretreatment process were observed among the different willow genotypes. The two pretreatment levels impacted polysaccharide accessibility differently among the cultivars. At the high severity pretreatment the cultivar, 'SV1', was the least recalcitrant, with sugar release representing up to 60% of total biomass. Correlations with sugar release and cellulose composition along with ethanol yield were identified. Further analysis of biomass chemical composition and wood properties will be necessary to define traits for the breeding and selection of shrub willow cultivars that are less recalcitrant to conversion.

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FIELD-BASED EXPERIMENTS ON LOW-LIGNIN SWITCHGRASS AS A FEEDSTOCK FOR LIGNOCELLULOSIC BIOFUEL PRODUCTION

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Switchgrass (Panicum virgatum L.) is a warm-season C4 perennial grass that is native to the prairies of North America. High biomass production and wide adaptation has made switchgrass a leading candidate for a dedicated lignocellulosic feedstock. One of its major limitations is the recalcitrance of complex carbohydrates to hydrolysis for conversion of lignocellulosic biomass into ethanol. Lignin is a primary contributor to recalcitrance as it creates a physical and chemical barrier to enzymatic access of cell wall polysaccharides. Therefore, genetic manipulation of the lignin biosynthetic pathway in an effort to reduce lignin content is a promising approach for overcoming this inherent cell wall recalcitrance. Low-lignin transgenic switchgrass plants were produced via down-regulation of caffeic acid Omethyltransferase (COMT), or by overexpression of the MYB4 transcription factor, an R2R3 type MYB repressor of the lignin biosynthetic pathway. Resulting greenhouse-grown COMT transgenic plants exhibited increased ethanol yields by up to 38% compared to the control and required less severe pretreatment and 300-400% less cellulase enzyme loading (Fu et al., 2011).

Greenhouse-grown MYB4 overexpression transgenic plants demonstrated 3-fold increase in sugar release efficiency (Shen et al., 2011). Field trials of COMT and MYB transgenic switchgrass are underway in Knoxville, Tennessee where plants are being assessed during a period of two-to-three growing seasons for 1) agronomic biomass performance (tiller height, plant width, tiller number) and biomass yield, 2) cell wall characterization, 3) biorefinery performance, including pretreatment response, sugar release efficiency, and ethanol yield, and 4) pest response, especially switchgrass rust incidence on transgenic plants and controls.

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ESTABLISHMENT OF PERENNIAL ALLEY CROPPING SYSTEMS ON RIPARIAN SOILS FOR BIOENERGY FEEDSTOCK PRODUCTION

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Alley cropping systems have been proposed as a means of producing biomass feedstock that support the development of bioproducts and bioenergy industries while also providing critical ecosystem services such as water quality improvement, wildlife habitat, and carbon sequestration. Strategic placement of these systems in riparian areas will maximize ecosystem services and reduce competition with food crops for prime upland acres. However, little is known about the performance of bioenergy crops in such systems. Optimizing establishment and growth of these crops is essential to realizing highly productive agroecosystems and expanding landowner adoption. Therefore, the objective of this study is to determine establishment and yield parameters associated with the production of perennial bioenergy crops in a riparian alley cropping system. In May 2010, two short rotation woody crops and four herbaceous bioenergy crops were established in replicated alley cropping systems at two riparian sites in Minnesota, U.S.A. Crop plant establishment and growth has been characterized for each species and biomass production along the tree-crop interface was compared to that in the center of the alley to test for effects of competition between the herbaceous and woody components. Repeated flooding has provided an opportunity to evaluate crop flood tolerance and suitability for riparian sites. Results from the 2010 and 2011 growing seasons will be reported.

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SCIENCE LOOKS TO UNLOCK POTENTIAL IN THE UNDOMESTICATED TREE THROUGH PRECISE GENETIC BREEDING

Lawrence D. Sullivan, Maud Hinchee, Michael Cunningham, Bijay Tamang

NREL and Scientific advances are unlocking ever more significant uses for the components of trees. In addition to the wood, pulp for paper and wood for fire, increasing demands are being made of trees for fine grade cellulosic sugars that can be converted to biofuels, polyethylene and other compounds for industrial use. Yet the tree itself remains an undomesticated plant. Far from its agricultural counterparts which have been bred for cold tolerance, drought resistance, improved yields and improved food quality, the tree has only been bred for a few generations and predominately to improve form for processing lumber. ArborGen uses advance breeding techniques to shorten the time required to reach domesticated species for industrial purposes. Varietal propagation allows us to replicate one species to improve consistency. Mass Controlled Pollination allows us to improve a line by controlling one parent in a breeding pair. However, demands for wood cellulose are growing at a rate of acceleration that can never be matched at the conventional breeding level for a species that takes more than 20 years to mature. ArborGen scientists use precision breeding techniques to look at specific ways of improving and domesticating trees for industrial uses. One excellent example is a ligninmodified Eucalyptus species that has proven to release more than twice the usual amount of sugar, making it a promising option as a biomass feedstock for liquid fuel. The tree is being studied by National Renewable Energy Lab (NREL). Using plant biotechnology the modifications were made at two points in the lignin biosynthetic pathway, with the largest increase in sugar release coming from cinnamate-4- hydroxylase (C4H) down-regulation. Although some “low recalcitrance” plant lines suffer from reduced growth, many of the C4H downregulated lines from the E. grandis x E. urophylla cross grow well. C4H lines have an estimated biomass productivity of ten dry-tons per acre per year, with the potential to produce about 1,000 gallons of liquid biofuels per acre. Scientists from NREL have characterized the C4H lines as containing half the lignin of the unmodified lines. Using a high throughput sugar release assay developed at NREL (Selig et al, 2011 Biotech. Letters 1-7), the modified lines were found to release up to 99 percent of their sugars, up from 40 percent in the non-modified plants. This result translates to an improvement of 150 percent, a dramatic demonstration of the impact of lowering recalcitrance. Further work by NREL and ArborGen on these and similar lines will aim to understand exactly how the recalcitrance is lowered and how this knowledge can be used to develop healthy low recalcitrance lines in an array of species.

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HIGH TONNAGE HARVEST AND TRANSPORT SYSTEMS FOR SOUTHERN PINE ENERGY PLANTATIONS

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This paper describes a research and development project to design and demonstrate a high-productivity, low-cost system to harvest, process, and transport woody biomass from southern pine energy plantations to biorefineries. Objectives of this project are to: 1) develop design improvements in tree-length harvesting machines (feller bunchers and skidders) for energy plantations; 2) assemble a highproductivity, lowest-cost harvesting and transportation system for biomass from southern pine energy plantations; and 3) demonstrate at full industrial scale and document performance of the harvesting, storage, pre-processing, and transportation system to provide the lowest delivered cost and optimal product quality for woody biomass. The paper will begin with discussion of results from benchmarking studies to document harvest and transport costs using traditional wheeled feller bunchers and grapple skidders working in pine plantations. The paper will then describe the design of a new track-type feller buncher and wheeled skidder combined with a whole-tree disk chipper and high capacity chip transport trailers. The tracktype feller buncher is equipped with a high-speed shear felling head, innovative hydraulic controls for boom movement, numerous energy efficiency features, and engine and exhaust systems that meet EPA Tier IV requirements. The wheeled skidder is equipped with the industry's largest grapple to maximize productivity. Initial productivity and cost data will be discussed for the high tonnage system based on field tests in clearcuts of 10 to 15 year old pine plantations. Additional discussion will be provided on biomass quality from various testing scenarios that include transpirational drying of the biomass.

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COMPARISON OF LIGNIN AND CARBOHYDRATE ANALYSIS USING PYROLYSIS-MOLECULAR BEAM MASS SPECTROMETRY, PYROLYSIS-GAS CHROMATOGRAPHY MASS SPECTROSCOPY AND WET CHEMISTRY

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Biomass Characterization The cell wall constituents, mainly cellulose, hemicelluloses and lignin, are critical determinants for feedstock biomass utilization. Analytical pyrolysis, which thermally degrades polymers into smaller fragments, can be coupled with various mass spectrometry (MS) techniques to provide both a "fingerprint" and an in-depth structural analysis of biomass. It has the advantage of higher throughput than the conventional wet chemistry methods. This study compares analysis of total lignin content, monolignol (S- , G- and H-subunit) composition and carbohydrates (C5 and C6) using pyrolysis-Molecular Beam Mass Spectrometry (py-MBMS), pyrolysis-Gas Chromatography Mass Spectrometry (py-GCMS) and wet chemistry methods. Populus, Eucalyptus and Pinus wood samples, including reaction wood, with a wide range of lignin and carbohydrate contents and monolignol composition were used in this study. The results showed that plants with different cell wall composition can be easily identified by py-MBMS, whereas py-GCMS offers a higher-resolution analysis of the lignin structure. Their utility in carbohydrate analysis, as well as platform-specific limitations in biomass characterization will be discussed. This study shows that py-MBMS is wellsuited as a high throughput screening platform, and that a multi-pronged approach is necessary for in-depth analysis of biomass samples with unusual characteristics. The py- MBMS and py-GCMS facility is supported by the Bioenergy Systems Research Institute and the Complex Carbohydrate Research Center at the University of Georgia, and offers analytical services for biomass characterization to the bioenergy community.

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ENHANCING BUTANOL PRODUCTIVITY THROUGH IMPROVED UTILIZATION OF BIOMASS BY CLOSTRIDIUM BEIJERINCKII NCIMB 8052

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Due to our long-standing interest in Clostridium beijerinckii NCIMB 8052, a model microorganism for studying acetone-butanol-ethanol (ABE) fermentation, the overarching goal of this study is to address some of the bottlenecks that prevent large-scale industrial production of butanol, a fossil fuel alternative. Key factors that impede effective sugar utilization result from (i) butanol's microbial toxicity and (ii) carbon catabolite repression (CCR) in solventogenic clostridia. We are attempting to address these two limitations. First, we integrated in situ vacuum-aided recovery of butanol into C. beijerinckii ABE fermentation and increased butanol productivity by 2- fold. Second, we are investigating the use of RNase P (ribozyme)-based gene knock-down methods to down-

regulate expression of CcpA, a transcription factor that decreases pentose utilization when glucose is still available. Motivated by a recent report (Wesolowski et al., 2011), we designed a cell-penetrating peptide-morpholino conjugate, with the latter's sequence complementary to the CcpA mRNA. The objective is to generate a bipartite (CcpA mRNA•Peptidemorpholino) complex that is recognized and cleaved by endogenous RNase P, a tRNA processing enzyme. Although preliminary data from this approach showed no significant utilization of pentoses by C. beijerinckii, we unexpectedly observed 11% and 18% increases in initial glucose utilization in media containing glucose (40 g/L) + arabinose (20 g/L) and glucose (40 g/L) + xylose (20 g/L), respectively, and a 25% increase in total ABE production in both cases. While we will investigate the bases for these increases, we are also pursuing in parallel variants of the RNase P-based approach.

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ENERGYCANE CROP ESTABLISHMENT AND FLOOD TOLERANCE IN A TEMPERATE CLIMATE

Ryan P. Viator[a]

Most energycanes have more vigor than sugarcane because energycane usually contains a higher percentage of genes from Saccharum spontaneum compared to commercial sugarcanes. Two studies were conducted to determine the relative difference between energy and sugarcanes when grown under less than optimal growing conditions. In study one, yields of cane, sucrose, and fiber of three sugarcane varieties and one energycane variety were compared when planted on August 1 (optimal time), September 1, and October 1. Fiber yields were 2.4 Mg ha^{-1} higher in cane planted in August than the averages in September and October for all varieties. There were no differences between the fiber yields for cane planted in September and October for all varieties, but sucrose yields declined with each later planting date. Thus, when planting cane at non-optimal times, energycane may be a better option than sugarcane in a sugarcane/energycane companion cropping system. In study two, two high biomass energycane varieties and two sugarcane varieties were planted and periodically flooded to determine which performed better under these stressinduced field conditions. The evaluation was conducted for two complete caneproduction cycles. Energycane tolerated the flooded conditions better than sugarcane when fiber and sucrose yields were compared between treatments. Tolerance to flooding was demonstrated in the plant cane and ratoon crops of L 79-1002, and in the ratoon crops of Ho 01-12. Therefore, an alternative to sugarcane in flood prone areas would be energycanes.

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MISCANTHUS X GIGANTEUS BIOMASS FEEDSTOCK PRODUCTION AND SUSTAINABILITY STUDIES IN THE EASTERN U.S.

Thomas Voigt[a], Mathew Maughan[b], Gevan Behnk[c], Rebecca Arundale[d]

Miscanthus x giganteus has been identified as a potentially productive biomass feedstock in both Europe and the U.S. The objective of this research was to determine the growth and development, productivity, and environmental sustainability of M. x giganteus in several field studies conducted in the Eastern U.S. In one study conducted in four environments (IL, KY, NE, and NJ), nitrogen was applied annually at 0, 60, and 120 kg ha^{-1} to M. x giganteus. Following the third year of growth, there were significant biomass yield differences among sites and years, but there were no significant biomass production differences among N fertilizer levels within individual sites and years. At the IL site, greenhouse gas emission fluxes, nitrate leaching, and N levels in harvested biomass were determined during the second and third growing seasons in a second study. During the third growing season, there was significantly more N_2O emitted, NO_3- leached, and N in the harvested biomass from the 120 kg ha^{-1} plots than from the other N applications. Given that there were no biomass yield differences due to N fertilization levels, this research indicates that high levels of N fertilization may cause both financially and environmentally negative results. In a final study, M. x giganteus and Panicum virgatum (switchgrass) were produced in side-by-side plots in eight IL locations and 9 additional Eastern U.S. locations. Biomass yields for both M. x giganteus and Panicum virgatum varied greatly due to growing environment and switchgrass variety.

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INNOVATIVE ALGAE DEWATERING TECHNOLOGY

A.R. Völkel, H. B. Hsieh, N. Chang, K. Melde, A. Kole

This paper describes a novel technology for dewatering of bio materials, such as algae, for biofuel production and other applications. This hydrodynamic separation (HDS) technology uses customized fluid flow patterns to focus suspended particulates into a well-defined band near a side wall of a curved channel, and where they can be separated off with a suitably designed flow splitter. The novel and innovative capability of this system is its ability to separate particles of any density, including neutrally buoyant

particles such as algae and other biological and/or organic matter, from a liquid without the use of a physical barrier. Advantages of this technology over conventional practice include: small foot print, low energy requirement, rapid process, and continuous flow operation. We explored the dewatering of different algae species including Spirulina, Chlorella Vulgaris, and S. dimorphus. Larger algae or algae that naturally form larger aggregates can be concentrated very efficiently without the use of any added chemicals and harvesting efficiencies up to 97% have been demonstrated. This makes HDS very attractive for the dewatering of algae from concentrations typical for open ponds (<0.1%) to above 1 % dry weight, where the addition of flocculants, which is needed for most other dewatering technologies, is costly and may add constraints to the reuse of the clean stream.

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EFFECT OF SOIL MOISTURE ON ECOSYSTEM RESPIRATION AND ITS RELATIONSHIP WITH SOIL TEMPERATURE IN SWITCHGRASS

Pradeep Wagle, Vijaya Gopal Kakani

Understanding the response of ecosystem respiration (ER) to major environmental drivers is critical for estimating carbon sequestration and large-scale modeling research. Temperature effect on ER is modified by other environmental factors, mainly soil moisture, and such information is lacking for switchgrass (Panicum virgatum L.) ecosystem. The objective of this study was to examine seasonal variation in ER and its relationships with soil temperature and moisture in a switchgrass field. Ecosystem respiration from the nighttime net ecosystem CO_2 exchange measurements by eddy covariance system was analyzed. Nighttime ER ranged from 2 (early May) to 10 µmol m-2 s^{-1} (mid-August) and showed a clear seasonality with low rates during warm (> 30 °C) and dry periods (< 0.20 m3 m-3 of soil water content). No single temperature or moisture function described the variability in ER over the whole season. However, exponential temperature model accounted for 59% of the seasonal variation in ER at adequate soil moisture (> 0.20 m3 m-3), indicating that soil moisture < 0.20 m3 m-3 started to limit ER. Temperature sensitivity (Q10) for ER showed linear relationship (R2 = 0.99) with soil moisture up to 0.30 m3 m-3 and then decreased due to limitation of soil-atmosphere gas exchange in wet soil. The Q10 values were 1.45, 1.91, 2.57, and 1.81 for soil moisture classes of 0.14 – 0.19, 0.20 – 0.24, 0.25 – 0.29, and 0.30 – 0.54 m3 m-3, respectively. These results suggest that soil moisture greatly influences the dynamics of ER and its relationship with soil temperature in droughtstressed switchgrass ecosystem.

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GREEN-CANE HARVEST OF SUGARCANE EFFECTS ON BIOMASS AND ENERGY YIELDS AND NUTRIENT REMOVAL

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Sugarcane yields in Louisiana can approach 40 dry Mg ha^{-1}, making sugarcane an attractive biofuel feedstock as well as a profitable sugar crop. Existing technology used in green-cane harvesting can be used to allow chopper harvester extractor fans to remove variable amounts of extraneous leaf material from the cane stalk and deposit it on the soil surface during harvest. The objectives were to (1) evaluate biomass and energy yields of selected sugarcanes, (2) estimate residue nutrient losses, and (3) evaluate logistics of harvesting at different extractor fan speed settings simulating sugar or biomass harvest. A commercial sugarcane variety HoCP 96-540 and a high-fiber "energycane" variety L 79-1002 were planted in 2009 and the plant cane was harvested in Nov. 2010 and first stubble in Oct. 2011. Three fan speeds were used: (1) Optimal range of 750 rpm for sugar harvest; (2) Fans turned off to simulate biomass harvest; and (3) mid-range of 375 rpm to deposit some crop residue. For plant cane, L 79-1002 (38 dry Mg ha^{-1}) produced more biomass than HoCP 96-540 (31-32 dry Mg ha^{-1}). For first ratoon, the varieties produced the same biomass (32 dry Mg ha^{-1}). Slowing or stopping extractor fans increased dry biomass yield by up to 13 Mg ha^{-1}. However, turning off extractor fans increased nutrient removal from field by 9.6, 2.5, and 14 kg of N, P2O5, and K2O ha^{-1}, respectively, when compared to the 750 rpm fan speed. The biomass harvest strategy with the harvester's extractor fans turned off, designed to remove as much total biomass as possible, increased the number of cane wagon loads by a factor of 1.6, due to lower density of crop residue. Adoption of biomass harvest strategy using existing sugarcane harvest technology produced dry feedstock yields of 39 Mg ha^{-1}, but the nutrient losses associated with residue removal may make lower yields more sustainable.

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LIGNIN AS A MATERIAL PLATFORM FOR BIO-DERIVED MACROMOLECULES AND FIBERS

Meghan E. Wilt[a], Maryam Mazloumpour[a], Orlando Rojas[b], Julie A. Willoughby[a]

The abundance of lignin, the second major component of wood and annual plants, provides an ample feedstock for conversion to viable macromolecule materials. Our research focuses on the production of high-value added materials derived from lignin including micro- and nano- fibers, surfactants for fuel emulsions, and resin-coated proppants. Our initial work evaluated the compatibility of silicon-containing plasticizers with a commercial kraft lignin, Indulin AT. Lignin's highly branched molecular structure limits it use as

a carbon fiber precursor due to its inherent brittle nature. Lignin's rich carbon content and abundance in nature highly motivates the elimination of this challenge. Utilizing an inherently flexible poly(dimethylsiloxane) (PDMS) co-polymer, we successfully electrospun core-sheath (lignin-PDMS) microparticles and microfibers. Tuning the morphology of the resultant materials is enabled through control of solvent, viscosity, and surface tension of the initial formulation. Preliminary thermal analysis data indicates an interaction between the silicon-containing component and Indulin AT. This work represents a key starting point for fundamental understanding on the interfacial compatibility between these two components. Future work aims to convert the particles and fibers to ceramic-carbon materials through pyrolysis.

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EPIDEMIOLOY OF PUCCINIA EMACULATA (RUST) IN SWITCHGRASS

M. Windham[a], J. Black[a], Q. Cheng[a], A. Windham[a], W. Copes[b], M. Newman[a], Y. Li[c]

In four fields, individual leaves of twenty-five switchgrass plants were rated once per week for fifteen weeks over two growing seasons for rust disease severity. Rust was first observed on Julian day 166 and 152 in 2010 and 2011, respectively. Switchgrass plants was at the 5-7 leaf growth stage when rust was first observed. Disease severity progressed logistically after detection from mid-June to mid-August. Leaf mortality was first observed in mid-to-late June. Greater than five percent of leaf surfaces were covered with uredia by early-to-mid October. An antagonist, Sphaerellopsis filum was observed in production fields parasitizing P. emaculata. To evaluate the mycoparasite's ability to impede urediospore production and viability, uredia of P. emaculata on detached switchgrass leaves were inoculated with conidia of S. filum. Pycnidia formed in uredia at 12-14 days after inoculation. The mycoparasite significantly reduced the number of urediospores per uredium by an average of 246 spores when compared to untreated uredia. When germination of urediospores was compared between healthy or those parasitized by S. filum, percent germination was 73% and 42%, respectively. Germ tubes of urediospores from healthy uredia averaged 96.9 um in length, whereas those from parasitized uredia averaged 32.3 um at three hours after germination. Epidemiology data can be used to predict when rust is likely to occur and when fungicides could be used to reduce disease severity. The antagonist may present an option to reduce inoculum needed by the rust to 'fuel' epidemics.

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BIO-ENERGY FOREST PLANTATIONS FOR THE SOUTHEASTERN UNITED STATES

Jeff Wright

Bio-energy forest plantations will supplement woody biomass from other sources such as logging residues. In the southern US, projections are for an increase of up to 25 million "new" tons of woody biomass demand for bio-energy. To supply this woody biomass demand will require purpose grown plantations of various species including pine, eucalypts, sweetgum, hybrid poplar and cottonwood, amongst others. Forest plantation yields can be 8-15 green tons/ acre/year on rotations of 5-12 years. Utilization of this renewable and sustainable biomass resource will be as feedstock "designed" for a large number of bio-energy applications.

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PRODUCTION POTENTIAL OF WOODY ENERGY CROPS IN THE STATE OF CONNECTICUT, USA

Zhao Xue, Liqin Qu, Yi Li, Xiusheng Yang

A land-use suitability model was developed and used for quantifying production potential of woody energy crops (hybrid poplar) in the State of Connecticut. The model included an exclusion area section, an ecological suitability section, and an economic/land-use suitability section, integrated onto a geographic information system (GIS) platform. The model was used to map the marginal land for hybrid poplar silviculture as a biofuel plant in Connecticut and to estimate the ethanol production potential, at both state and county levels. About 40% of the land was excluded from the purpose while only one half of the remaining 60% was regarded suitable for hybrid poplar silviculture. The percentage of usable area was highly variable at the county level. The total area of usable land parcels was 603,117 acres and 1/3 of them would have to be used for hybrid poplar cultivation to fulfill the ethanol demand of the State. It appears that the production capacity of woody energy crops is not adequate to meet the demand for ethanol use of the State but rather a supplemental feedstock.

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DEVELOPMENT OF A PROCESS-BASED HERBACEOUS BIOENERGY CROP MODEL

Yubin Yang[a], Lloyd Ted Wilson[a], Jiale Lv[a], Jenny Wang[a]

The objectives of this study are: 1) Determine the phenotypic traits that govern bioenergy crop growth and development; 2) Develop an individual-based herbaceous bioenergy crop model that captures the temporal and spatial dynamics of crop growth and development; 3) Conduct comprehensive analysis on the genotype (G) × environment (E) × management (M) interactions to identify site-/genotype-specific management practices for optimal biomass production. Field experiments were conducted between 2009-2010 to determine major phenotypic traits for three genotypes of biomass sorghum through both in-field observations and multiple destructive samplings. Results for major phenotypic traits were used for model parameter estimation. The process-based crop model is based on our integrated functionalarchitectural modeling framework that simulates the temporal and spatial dynamics of plants. The functional component of the system incorporates major physiological processes and simulates the growth and development of individual organs, integrated to an individual plant and a population of plants. The architectural component of the system includes an architecture engine that constructs 3D plants based on the physiological states of its organs. The model will be used to simulate biomass productivity for integrated bioenergy supply chain analysis.

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DETERMINATIONS OF MECHANICAL PROPERTIES OF PELLETIZED BIOMASS AND FUNDAMENTAL MECHANICAL PROPERTIES OF GRANULAR BIOFEEDSTOCK

Hojae Yi, Apoorva Karamchandani, Virendra M. Puri, Daniel Ciolkosz

Low bulk density of biomass prevents its optimized usage. Densification is one promising approach that can overcome this issue. Since pelleting machines require relatively low energy input, pelletization is considered a promising densification method. However, the mechanical quality of produced pellets has not been studied using lab/pilot scale pelletizers extensively, which limits scale-up ability to optimize the pelletization process reliably. As the need for renewable bioenergy and bioproducts increases, it is important to establish a foundational knowledge base from which one can engineer efficient supply chain networks and optimum downstream processes. This includes quantification of pellets' quality-related mechanical properties. Since the mechanical properties of densified biomass are a direct consequence of the properties of the raw material, i.e. granular biofeedstock, quantitative knowledge of its physical and mechanical properties is essential. The feasibility of relating granular materials' mechanical properties in the lowpressure regime (typically <10 MPa) to the quality attributes of densified compacts was recently established. In this approach, the first step is to determine the fundamental mechanical properties of granular biofeedstock and mechanical properties of densified pellets. Based on the measurements, predictive relationships can be developed and a theoretical explanation for the validity of the relationships can be proposed. The predictive relationship that arises from this approach is a valuable tool for engineering, monitoring, and controlling the quality of densified granular biofeedstock; which is a critical raw material contributing to the expanding bio-based renewable energy industry.

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SPATIALLY-DEFINED OPPORTUNITY ZONES FOR CELLULOSIC BIOMASS SUPPLY INTEGRATED WITH THE BIOSAT MODEL

Timothy M. Young[a], James H. Perdue[b], Xia Huang[a]

Those working towards sustainable solutions must take into consideration the conditions and relationships among the environmental, social, and economic spheres locally, as well as at the broader landscape scale. Each of these factors affects the amount and type of biomass that are potentially available given the economic and societal regulatory constraints on total available biomass supply. Key to ensuring sustainable cellulose supply is the spatial assessment of the economic availability of woody and agricultural cellulosic biomass feedstocks. Policy makers, businesses, and investors need to identify implications of external variables on bio-based market conditions to better guide bio-based market organization decisions.

This study explores the biophysical environment and its impacts on biomass access and the measure to which competing land uses are physically restricted by current land use and will include a spatial competition model and risk assessment for biomass resources. Data selected for variables and attributes include those from the natural and social-economic environments. Imagery enhanced decision support tools can provide rapid visualization to improve the ability to scrutinize bio-resource cost, consumption, and consequences. The resulting targeted landscape analysis will yield new analytical insights into likely biomass opportunity zones. This study builds upon work already completed and is an extension of the Biomass Site Assessment Tool (BioSAT) web-based system, http://www.biosat.net/. BioSAT contains transportation, harvesting, and resource cost models that provide spatially-explicit biomass economic supply curves for agricultural and forest bio-basins at a 5-digit ZIP Code Tabulation Area (ZCTA) resolution providing 25,307 potential analytical polygons or site locations.

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FEEDSTOCK COSTS AND TRANSPORTATION EMISSIONS AND THEIR IMPACT ON THE SITE SELECTION OF A SWITCHGRASS-BASED BIOREFINERY: A CASE STUDY OF TENNESSEE

T. Edward Yu[a], Joshua S. Fu[b], James A. Larson[a], Burton C. English[a]

This study evaluates the potential sites of switchgrass-based biorefineries in Tennessee by examining the plant-gate cost and truck emissions of delivering feedstock to biofuel production. Applying a spatial-oriented mixed-integer mathematical programming model using GIS data, we first estimate feedstock cost and identify the location of a single-feedstock biorefinery with the least cost in three different regions of the state, i.e. east, central and west Tennessee. Given the feedstock draw area and the road links for hauling feedstock to the biorefinery in each region, US Environment Protection Agency's Mobile Vehicle Emission Simulator (MOVES) model is used to estimate the emissions generated from hauling feedstock in the study region. Results show that feedstock costs and transportation emissions are affected by the degree of feedstock draw area dispersion and topography of the draw area around the biorefinery site. Based on feedstock costs and transportation emissions, the biorefinery is suggested to be located in Robertson County in central Tennessee. In addition, when the capacity of biorefinery is expanded, the enlarged feedstock draw area creates higher vehicle travel miles, resulting in more transportation costs and hauling emissions of feedstock. This implies that the improved production efficiency of the larger facility (i.e. economies of scale) needs to make up for the additional transportation cost.

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ANALYZING THE ECONOMICS OF AN ALTERNATIVE PREPROCESSING TECHNOLOGY IN THE SWITCHGRASS LOGISTICS SYSTEM FOR A BIOREFINERY IN EAST TENNESSEE

T. Edward Yu[a], James A. Larson[a], Burton C. English[a]

Currently, one of the significant challenges to the economic viability of a lignocellulosic biomass (LCB) biofuels industry is the substantial costs related to harvest, storage, and transportation of feedstock. The low density of LCB feedstock at harvest and the potential for dry matter losses (DML) during storage contribute to these costs. Using preprocessing methods to densify LCB feedstock can potentially reduce transportation and storage costs of biomass feedstock for biofuel production by condensing the feedstock's size. However, the capital costs of preprocessing facilities could be significant in the feedstock logistics system. The objective of this study is to evaluate the economics of adopting an alternative preprocessing facility in the switchgrass logistics for a commercial-scale biorefinery. Using a mixed-integer mathematical programming model and a GIS resource model, we compare the optimized plant-gate costs associated with two feedstock supply systems, i.) the conventional hay methods and ii.) a preprocessing technology that has been applied to woody biomass (stretch-wrap baling) for a potential switchgrass-based refinery with the annual capacity of 25 million gallons of biofuel in East Tennessee. Preliminary results suggest that preprocessing using stretch-wrap baling equipment to condense and prepare feedstock for storage had lower delivered costs than conventional round bale system. In contrast, feedstock plant-gate costs for the stretch-wrap baling system and the conventional square bale system were similar. Sensitivity analyses suggest that harvest method and the dry-weight of preprocessed bales have the largest impact on the economics of preprocessing feedstock.

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CHAR-BASED NI CATALYSTS FOR SYNGAS CLEANUP AND CONDITIONING IN BIOMASS GASIFICATION

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A newly developed nano-Ni on char catalyst was studied for syngas cleaning and upgrading in an updraft biomass gasifier. The nano-Ni/char catalyst was prepared by mechanically mixing nano-sized NiO powders with char particles and its performance was compared with Ni/char and Ni/-Al2O3 catalysts in terms of syngas composition enhancement and tar removal. The SEM/EDX analysis showed that nano-NiO particles uniformly distributed on the surface of char particles, with 66.3% Ni dispersion rate and 128.5 m2/g-Ni surface area. The effect of cracking temperature (650°C to 850°C), nickel oxide loading (5% to 20%), and gas residence time (0.1 to 1.2 s) on catalyst performance was studied. Nano-Ni/char catalyst showed better catalytic reactivity than Ni/char, also, nano-Ni/char showed higher reactivity than Ni/-Al2O3¬ at a relatively low temperature (~700°C).

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CHEMICAL AND ELEMENTAL COMPOSITION OF BIG BLUESTEM AS AFFECTED BY ECOTYPE AND PLANTING LOCATION ALONG THE PRECIPITATION GRADIENT OF THE GREAT PLAINS

Ke Zhang[a], Loretta Johnson[b], Richard Nelson[c], Wenqiao Yuan[d], Zhijian Pei[e], Donghai Wang[a]

Three big bluestem ecotypes from central Kansas (Cedar Bluffs and Webster populations), eastern Kansas (Konza and Top of the World populations), and Illinois (12Mile and Fults populations), as well as the Kaw cultivar, were harvested from four reciprocal garden planting locations (Colby, Hays, and Manhattan, KS; and Carbondale, IL) and evaluated for their chemical (glucan, xylan, arabinan, lignin and ash) and elemental (carbon, oxygen, hydrogen, nitrogen and sulfur) compositions. The objective of this research was to study the effects of ecotype and planting location on the chemical and elemental compositions of big bluestem along the Great Plains precipitation gradient (~1200 to 400 mm mean annual precipitation). All the populations revealed a large variation in cellulose (31.8–36.5%), hemicellulose (24.96–29.74%), lignin (14.4–18.0%), carbon (47.3–51.3%), and nitrogen (4.91–6.44%). Planting location had significant effects on both chemical and elemental compositions of big bluestem. Ecotype had significant effects on glucan, xylan, lignin, and ash contents as well as on carbon, oxygen, and hydrogen elemental fractions. In addition, the interaction between ecotype and planting location had significant effects on glucan, lignin, and hydrogen. Planting location had a greater effect on chemical and elemental compositions than the ecotype and interaction between location and ecotype. The total sugar content of the big bluestem (regardless of ecotype) increased as the Great Plains precipitation gradient increased from west to east. Annual precipitation, growing degree days and potential evapotranspiration in 2010 explained up to 97%, 88% and 80% of the variation in compositions respectively.

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BIOSOLAR CONVERSION OF CO_2 AND H2O TO LONG-CHAIN ALCOHOLS BY ENGINEERED CYANOBACTERIA

RLiping Gu[a], Xianling Xiang[a], Doug Raynie[b], William Gibbons[a], Ruanbao Zhou[a]

Biorefineries typically release one third of the carbohydrate carbon as CO_2 during fermentation, as well as significant amounts of low grade heat. Ideally, a photosynthetic organism could be engineered to convert these unused resources into high value chemicals. The current microalgae production model suffers from technical challenges including harvest cells, extract oils, and then convert them into a final product. We circumvented these challenges by engineering cyanobacteria to directly produce and secrete linalool (C10H18O: a high energy dense long-chain alcohol and "drop-in" biofuel) as a living factory using sunlight and CO_2 as the feedstock. Linalool is a naturallyoccurring terpene alcohol, emitted as a volatile compound from many flowers and spice plants. Cyanobacteria, like plants, have both the MVA pathway and the MEP pathway to produce geranyl diphosphate (GPP), the precursor for linalool. However, cyanobacteria lack the linalool synthase that plants use to convert GPP into linalool. In this project, the linalool synthase gene from Norway Spruce was fused to His6-tag driven by a dual Pnir–PpsbA1 promoter. The plant linalool synthase was overexpressed in transgenic Anabaena in which linalool was produced and secreted as monitored by GC-MS.

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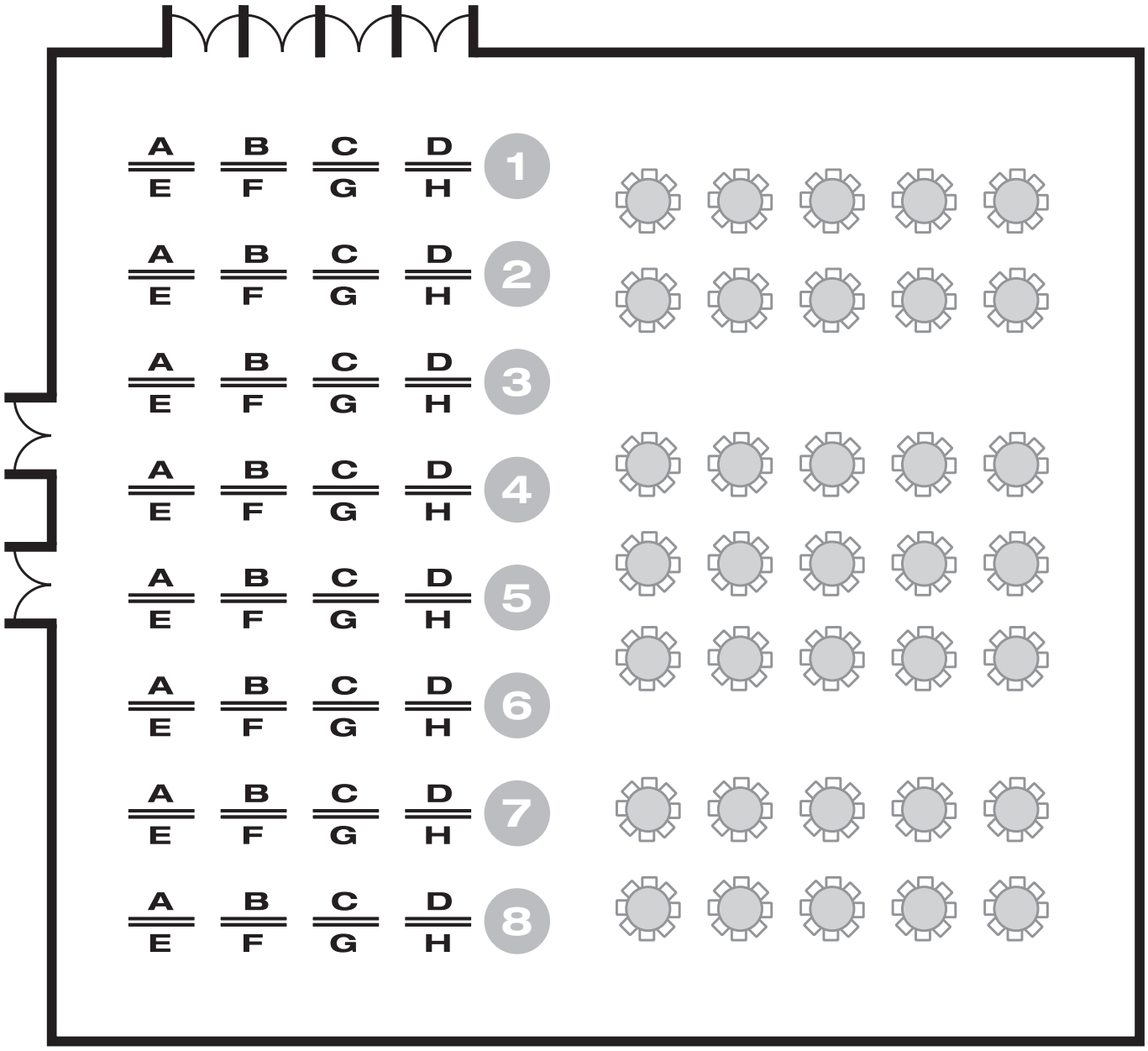
Nepolean Ballroom



1A DEVELOPMENT OF GENOMIC RESOURCES AND NOVEL SPECIES HYBRIDS FOR THE GENETIC IMPROVEMENT OF SHRUB WILLOW FEEDSTOCK CROPS

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1B IDENTIFICATION OF SUPERIOR POPLAR CLONES FOR THE PRODUCTION OF BIOFUEL IN THE LAKE STATES REGION

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1C BREEDING FOR AN UNIDENTIFIED INDUSTRY: OVERCOMING CHALLENGES TO ESTABLISH A PIPELINE OF NEW ENERGYCANE VARIETIES

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1D CHARACTERIZATION OF MAIZE CANDY-LEAF MUTANTS FOR IMPROVED BIOREFINERY FEEDSTOCK CHARACTERISTICS

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1E AN INITIATIVE MOLECULAR STRATEGY OF AMARANTH BREEDING FOR BIOMASS

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1F IMPROVED BIOENERGY SORGHUMS FOR THE SOUTHEASTERN US

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1G FIRST YEAR FIELD RESULTS OF ALTERED LIGNIN COMT-KNOCKDOWN SWITCHGRASS

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1H CREATING RENEWABLE ENERGY THROUGH SUSTAINABLE NUTRIENT MANAGEMENT PRACTICES

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GROWTH KINETICS AND LIGHT DYNAMICS IN CULTURES OF NANOCHLOROPSIS SALINA IN A FULLY AUTOMATED AND CONTROLLED ENVIRONMENT

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2B

COMPARING HYBRID POPLAR, WILLOWS AND NATIVE GRASSES: YIELD AND ENERGY VALUE

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2C

LEVERAGING THE SCIENCE OF PLANT PATHOLOGY TO MEET BIOMASS-TO-BIOFUELS CHALLENGES

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2D

BIOMASS PRODUCTION OF PRAIRIE CORDGRASS USING KURA CLOVER AS SOURCE OF NITROGEN

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SORGHUM BIOMASS AND DISEASE INTENSITY AS IMPACTED BY NITROGEN RATE AND VARIETY

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SWITCHGRASS YIELD RESPONSE TO NITROGEN ON FOUR SOIL TYPES IN WEST TENNESSEE

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EFFECT OF HARVEST DATE ON SWITCHGRASS QUALITY FOR BIOENERGY

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VERTICAL DISTRIBUTION OF CORN BIOMASS ON TWO SOIL TYPES OF THE SOUTHEASTERN US

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CHARACTERIZATION OF NUTRIENT-EMBEDDED BIOCHAR PELLETS AS A SLOW-RELEASE FERTILIZER MATERIAL

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3B

CHARACTERISTICS OF PRETREATED AND DENSIFIED BIOMASS

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3C

DIRECT HARVEST MOISTURE CONTENT AND COST DIFFERENCES FOR BIOMASS CROPS ACROSS SIX LOCATIONS IN THE SOUTH

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3D

ASSESSMENT OF THE MOST ADEQUATE PRE-TREATMENTS AND WOODY BIOMASSES INTENDED FOR DIRECT CO-FIRING IN THE U.S.

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3E

IN-WOODS SCREENING OF GRINDINGS FROM LOGGING RESIDUES TO IMPROVE BIOMASS FEEDSTOCK QUALITY

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3F

FIBER ANALYTICS: FACILITATING BIOENERGY DEVELOPMENT IN NORTH CAROLINA THROUGH THE USE OF A COMPREHENSIVE SPATIAL DATABASE AND INTERACTIVE MAPPING SERVICE

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3G

AN ONLINE BIOMASS RESOURCE ATLAS FOR PRELIMINARY FACILITY SITING AND RESOURCE ANALYSIS IN NORTH CAROLINA

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3H

ANALYZING THE IMPACT OF THE US RAIL TRANSPORTATION NETWORK ON BUILDING A SUSTAINABLE BIOENERGY FEEDSTOCK SUPPLY CHAIN

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ASSESSMENT OF PRODUCTION AND TRANSPORTATION PRACTICES FOR SWEET SORGHUM

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4B

AN UPDATE ON US PARTICIPATION IN ISO/TC 238 SOLID BIOFUEL STANDARDS DEVELOPMENT

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4C

COMPARISON OF SYNGAS FERMENTATION REACTORS FOR BIOLOGICAL ALCOHOL PRODUCTION

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4D

DIRECT CO-LIQUEFACTION OF COAL AND TORREFIED WOODY BIOMASS

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4E

CONVERSION OF BROWN SEAWEED INTO MIXED KETONES THROUGH CARBOXYLATE PLATFORM PROCESSING

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4F

DEVELOPMENT OF AN ACID SULFITE PROCESS TO PRETREAT EASTERN RED CEDAR FOR CELLULOSE HYDROLYSIS

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BIODIESEL-GLYCEROL CARBONATE PRODUCTION PLANT BY GLYCEROLYSIS

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4H

OPTIMIZING TAR CRACKING CATALYSTS FOR CLEANING SYNGAS FROM A BIOMASS GASIFIER

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BIODIESEL AS CO-SOLVENT FOR EXTRACTION OF LIPIDS FROM MICROALGAE IN A CONTINUES FLOW LIPID EXTRACTION SYSTEM

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5B

BIOMASS-BASED MODEL SYNGAS CO-FIRING WITH NATURAL GAS IN A LABORATORY AIR-SWIRLED BURNER: EFFECTS OF CO-FIRING RATES, COMBUSTION AIR-TO-FUEL RATIONS AND BURNER PORT AREA ON FLAME AND EXHAUST CHARACTERIZES

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CONVERSION OF AGRICULTURAL RESIDUES TO ACTIVATED CARBON

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METABOLIC NETWORK ANALYSIS OF XYLOSE METABOLISM BY PICHIA STIPITIS

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5E

PRETREATMENT METHODS FOR THE IMPROVEMENT OF BUTANOL PRODUCTION IN A FLUSHED SOLID STATE CULTIVATION SYSTEM USING CO-CULTURES OF CLOSTRIDIUM THERMOCELLUM AND CLOSTRIDIUM BEIJERINCKII ON AGRICULTURAL RESIDUES

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CARBON NANOFIBERS FROM ELECTROSPUN LIGNIN

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5G

ELUCIDATION OF POTENTIAL REACTION MECHANISM FOR OVERLIMING DETOXIFICATION IN ADVANCED BIOFUELS FERMENTATION

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5H

HYDROTHERMAL CONVERSION OF BIG BLUESTEM FOR BIO-OIL PRODUCTION

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ESTABLISHED CONSERVATION RESERVE PROGRAM STUDY: SPECIE SHIFTS, YIELD AND LIVESTOCK FEED VALUE IN NOT USED FOR BIOMASS

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6B

GREENHOUSE GASES FLUXES IN RESPONSE TO CORN STOVER HARVEST

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OPPORTUNITIES AND MITIGATION STRATEGIES FOR USING CORN STOVER AS A BIOENERGY FEEDSTOCK

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6D

SOIL CARBON DYNAMICS THREE YEARS FOLLOW CONVERSION OF MARGINAL SOILS TO COTTONWOOD AND SWITCHGRASS BIOENERGY CROPS

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6E

CRADLE-TO-GATE LIFE-CYCLE INVENTORY OF SWITCHGRASS FUEL PELLETS IN THE SOUTHEASTERN UNITED STATES

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REMOTE SENSING OF CROP RESIDUES COVER AND MODELING WATER AND SOIL QUALITY IN A CENTRAL IOWA WATERSHED

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6G

PREDICTING BIOMASS YIELD IN BIOENERGY CROP PRODUCTION SYSTEMS USING CANOPY NDVI

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DEVELOPMENT OF AN INTEGRATED BIOMASS PRODUCTION AND LOGISTICS ANALYSIS SYSTEM FOR THE U.S. GULF COAST

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ROLE OF CONTRACTS ON LAND USE CHANGE AND BIOMASS FEEDSTOCK SUPPLY

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BIOMASS LOGISTICS COMPLEXITIES AND MODELING IN AID OF SOLUTIONS

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BIOENERGY FROM RESERVE PRAIRIES IN MINNESOTA: METHODS FOR MEASURING HARVEST AND MONITORING WILDLIFE

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7D

ASSESSMENT OF POTENTIAL CAPACITY INCREASES AT COMBINED HEAT AND POWER FACILITIES IN MISSISSIPPI BASED ON AVAILABLE CORN STOVER AND FOREST LOGGING RESIDUE

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7E

BIOENERGY MARKET PENETRATION IN SOUTHEASTERN STATES: A FIVE-YEAR REVIEW

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7F

COMMUNITY GERMINATION STUDEIS FOR BIOENERGY FEEDSTOCKS IN NEW YORK STATE: STUDENT-DRIVEN AUTHENTIC RESEARCH IN HIGH SCHOOL SCIENCE CLASSROOMS

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EDUCATION AT THE SPEED OF RESEARCH: COMMUNICATING THE SCIENCE OF BIOFUELS

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7H

DEVELOPING NEW STRATEGIES TO IMPROVE THE COST EFFECTIVENESS OF MICROALGAL HARVESTING TECHNIQUES FOR BIODIESEL PRODUCTION

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OPTIMIZING DILUTION RATES AND LIGHT PENETRATION TO MAXIMIZE ALGAL LIPID PRODUCTIVITIES IN OUTDOOR CULTURES

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EFFECT OF MIXOTROPHIC ORGANIC CARBON ON THE LIPID PRODUCTION OF A MICROALGAE/CYANOBACTERIA CULTURE

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HYDROGEN PRODUCTION FROM MICROALGAE

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COMMERCIALIZATION OF IDENTITY PRESERVED GRAIN SORGHUM WITH OPTIMIZED ENDOSPERM MATRICES FOR ENHANCED BIOETHANOL CONVERSION AND HIGH LYSINE DDG FEED AND FOOD VALUE

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