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Switchgrass-Aphid Interactions – How Far Along Are We?

Grasslands In Colorado Agroecosystems Support Diverse Native Bee Assemblages

The Impacts Of Lignin Modifications On Fungal Pathogen And Insect Interactions In Sorghum

In Silico Identification And Characterization Of Nb-Lrr Encoding Resistance Genes In The Bioenergy Plant Switchgrass (Panicum Virgatum L.)

Integrating Flowcam And Fluorescence In Situ Hybridization (Fish) For Rapid Detection Of Brachionus Calyciflorus In Algal Culture:

Identification Of Genes Controlling Disease Resistance To Mitigate Disease Pressure Of Bioenergy Crops

A Water And Risk Management Tool For Sustainable Production Of Bioenergy Feedstocks

Carbon Sequestration And Greenhouse Gas Emissions Associated With Cellulosic Bioenergy Feedstock Production On Marginal Lands In The Lower Mississippi Alluvial Valley

Total Water Use And Source Partitioning In Woody Bioenergy Crops

Impacts Of Forest Biomass Removal On Soil Quality And Biodiversity

Regulation Of Trace Gas Fluxes And Production In A High Temperature Biofuel Production System: Measurements In Support Of Life Cycle Assessments

High Planting Densities For Southern Pine Bioenergy Feedstock Production: Filling In The Carbon Life Cycle Analysis

Examining The Impacts Of Pyrogenic Carbon On Organic Matter Storage In Forest Soils

Direct Effects Of Converting Conventional Cropping Systems To Biofuel Cropping Systems On Ecosystem Services For The Southeastern U.S.A.

Evaluating How Market And Policy Affect Cellulosic Biofuel Feedstock Production In Marginal Land Of Upper Midwest And Its Consequences On Water Sustainability In A Changing Climate

Water Yield And Quality Through An Integrated Woody And Herbaceous Biofuel Feedstock Production System

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# USDA-NIFA AFRI Sustainable Bioenergy Annual Project Director (PD) Meeting Agenda

**October 29-31, 2014**  
**Renaissance Capital View Arlington Hotel**  
**2800 South Potomac Ave**  
**Arlington, VA 22202**

## Wednesday, October 29, 2014

<table>
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<tr>
<th>Time</th>
<th>Event</th>
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| 3:00-4:30 PM   | Prefunction  
Poster Set-Up and Registration  
*Virginia Polytechnic Institute And State University Staff* |
| 4:30 – 5:00 PM | Salon 1-2  
Welcome And Opening Remarks  
*Dr. Louie Tupas, Director, Institute of Bioenergy, Climate and Environment, NIFA* |
| 5:00 – 6:30 PM | Foyer of Salon 1-3  
Poster Session #1 And Networking Reception |

## Thursday, October 30, 2014

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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| 7:00-8:30 AM   | Prefunction  
Continental Breakfast, Poster Set-up and Registration  
*Virginia Polytechnic Institute and State University Staff* |
| 8:30 – 9:00 AM | Salon 1-2  
Welcome And Opening Remarks  
*Dr. Sonny Ramaswamy, Director, NIFA* |
| 9:00-9:30 AM   | Salon 1-2  
System For Advanced Biofuels Production From Woody Biomass In The Pacific Northwest  
*Dr. Richard Gustafson*  
*University of Washington* |
| 9:30-10:00 AM  | Salon 1-2  
Northwest Advanced Renewables Alliance (NARA): A New Vista for Green Fuels, Chemicals, and Environmentally Preferred Products (EPPs)  
*Dr. Michael Wolcott*  
*Washington State University* |
| 10:00-10:30 AM | Salon 1-2  
Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (AFRI-CAP)  
*Dr. Kenneth Moore*  
*Iowa State University* |
| 10:30-10:45 AM | BREAK |
| 10:45-11:15 AM | Salon 1-2  
A Regional Program for Production of Multiple Agricultural Feedstocks and Processing to Biofuels and Biobased Chemicals  
*Dr. Donal Day*  
*Louisiana State University Agricultural Center* |
| 11:15-11:45 AM | Salon 1-2  
Southeast Partnership for Integrated Biomass Supply Systems  
*Dr. Timothy Rials*  
*University of Tennessee* |
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Details</th>
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<tr>
<td>11:45-1:15 PM</td>
<td>LUNCH (on your own)</td>
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| 1:15-1:45 PM     | Salon 1-2                       | NEWBio: Northeast Woody/Warm-Season Biomass Consortium  
Dr. Thomas Richard  
The Pennsylvania State University |
| 1:45-2:15 PM     | Salon 1-2                       | Sustainable Biofuel Feedstocks From Beetle-Killed Wood: Bioenergy Alliance Network Of The Rockies (BANR)  
Dr. Keith Paustian  
Colorado State University |
| 10:30-10:45 AM   |                                | BREAK                                                                                           |
| 2:30-4:30 PM     | Concurrent Sessions            |                                                   |
| Track 1: Studio A| Enhanced Value Co-Product Development  
Led By Dr. Shing Kwok, NIFA National Program Leader  
Engineering Neurospora Crassa For Improved Cellobionate Production From Cellulosic Biomass  
Dr. Zhiliang Fan  
University Of California-Davis  
Regioselective Synthesis Of Cellulose Derivatives Without The Need For Protecting Groups  
Dr. Kevin Edgar  
Virginia Polytechnic Institute And State University  
Engineering High Value Oil Production Into Biofuel Crops  
Dr. Joseph Chappell  
University Of Kentucky  
Engineering *Lactobacillus Casei* For The Production Of L(+)-Lactic Acid From Renewable Feedstocks  
Dr. Jeff Broadbent  
Utah State University |
| Track 2: Salon 3 | Wildlife Pollinators & Crop Protection  
Led by Dr. Mary Purcell, NIFA National Program Leader  
I. Crop Protection  
Landscape Structure And Natural Pest-Suppression Services In Bioenergy Landscapes: Implications For Regional Food And Fuel Production  
Dr. Claudio Gratton  
University of Wisconsin  
Managing Insect Pests and Diseases in Multi-Use Landscapes of Bioenergy and Conventional Cropping Systems in the Gulf Coast  
Dr. Ted Wilson/ Dr. Gene Reagan  
Louisiana State University  
Control and Mitigation of Generalist Pests in Perennial Grass-Dominated Bioenergy Landscapes  
Dr. Carolyn Malmstrom  
Michigan State University |
### Salon 3 (continued)

**Impact Of Bioenergy Crops On Pests, Natural Enemies And Pollinators In Agricultural And Non-Crop Landscapes**  
**Dr. Kris Giles/ Dr. Tim Kring**  
**University Of Arkansas**  
The Role Of Diversified Bioenergy Cropping Systems In Enhancing Biological Control Of The Soybean Aphid.  
**Dr. Gregg Johnson**  
**University Of Minnesota**

### II. Wildlife Pollinators

Evaluating The Sustainability Of Bioenergy Production In The Southeast On The Basis Of Wildlife And Pollinator Responses Across Spatial Scale  
**Dr. Rob Fletcher**  
**University Of Florida**  
Promoting Pollinators And Other Beneficial Insects Through Bio-Oil Production  
**Dr. Frank Forcella**  
**Usda Agricultural Research Service**  
Multi-Scale Assessment Of Wildlife Sustainability In Switchgrass Biofuel Feedstock Production In The Eastern Us  
**Dr. Patrick Keyser/Chris Lituma**  
**University Of Tennessee**

### Track 3: Salon 1-2

**Carbon Sequestration, Land Use & Water**  
Led by Dr. Nancy Cavallaro, NIFA National Program Leader  
Contributions Of Upland And Lowland Switchgrass Ecotypes Associated Mycorrhizal Fungi To Soil Carbon Storage  
**Dr. Gail Wilson**  
**Oklahoma State University**  
At The Root Of Sustainable Bioenergy: Using Genetic Variation In Root Traits To Maximize Soil Carbon Sequestration And Biomass Yields  
**Dr. Marie-Anne de Graaff**  
**Boise State University**  
Greenhouse Gas Emission And Carbon Mineralization In An Eroded Landscape Amended With Biochar  
**Dr. Rajesh Chintala**  
**South Dakota State University**  
Carbon Sequestration And Gaseous Emissions In Perennial Grass Bioenergy Cropping Systems In The Northeastern U.S.  
**Dr. Brian Richards**  
**Cornell University**
<table>
<thead>
<tr>
<th>Track 4: Studio C</th>
<th>Policy Options &amp; Socioeconomic Impacts</th>
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<tr>
<td></td>
<td>Led by Dr. Fen Hunt, NIFA National Program Leader</td>
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<tr>
<td></td>
<td>Socioeconomic Impacts of Biofuels on Rural Communities</td>
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<td>Dr. A. E. Luloff</td>
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<td></td>
<td>Pennsylvania State University</td>
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<td>Social Acceptability of Bioenergy in the U.S. South</td>
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<td>Dr. J.Peter Brosius</td>
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<td>University of Georgia</td>
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<td>The Effect of Existing and Novel Policy Options on the Sustainable Development of Regional Bioenergy Systems</td>
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<td>Dr. Christopher Galik</td>
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<td>Duke University</td>
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<td>Evaluating Policy Incentives For Regional Biofuels Production Systems With A Scenario-Based Decision Support Tool.</td>
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<td>Dr. Claudio Gratton</td>
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<td>University of Wisconsin</td>
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4:30-6:00 PM Poster Session #2 & Reception

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**Friday, October 31, 2014**

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<tr>
<th>Time</th>
<th>Activity</th>
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<tr>
<td>7:00-8:00 AM</td>
<td>Continental Breakfast, Poster Set-up and Registration</td>
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<tr>
<td>Prefunction</td>
<td>Virginia Polytechnic Institute and State University Staff</td>
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<tr>
<td>8:00 – 8:30 AM</td>
<td>Introduction:</td>
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<tr>
<td>Salon 1-2</td>
<td>Dr. Daniel Cassidy, NIFA National Program Leader</td>
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<td>8:30: 9:00 AM</td>
<td>Place Based Opportunities For Sustainable Outcomes and High Hopes: POSOH</td>
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<td>Salon 1-2</td>
<td>Dr. Richard Amasino</td>
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<td>The Board of Regents of the University of Wisconsin System</td>
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<td>9:00-9:30 AM</td>
<td>Northeast Bioenergy and BioProducts (NBB) Educational Program: Providing Faculty with Training, Tools and In-classroom Support</td>
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<tr>
<td>Salon 1-2</td>
<td>Dr. Corine Rutzke</td>
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<td>Cornell University</td>
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<td>9:30 – 10:00 AM</td>
<td>BREAK</td>
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<tr>
<td>10:00 -11:30 AM</td>
<td>The Future of Bioeconomy and Audience Q&amp;A</td>
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<tr>
<td>Salon 1-2</td>
<td>Dr. Sonny Ramaswamy Director of NIFA</td>
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<tr>
<td>11:30-11:45 AM</td>
<td>Closing Remarks</td>
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<tr>
<td>Salon 1-2</td>
<td>Dr. Bill Goldner, Acting Division Director, NIFA</td>
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</table>
Welcome to the 2014 Agriculture and Food Research Initiative Sustainable Bioenergy Challenge Project Directors Meeting

This year's meeting is being held to bring together all our Sustainable Bioenergy Challenge Project Directors, with the National Institute of Food & Agriculture (NIFA) staff and leadership. Our goal in this meeting is to provide an opportunity for Projects Directors, administrators and stakeholders to learn and engage in discussions that will improve our understanding of sustainable bioenergy and biobased product issues and information to meet the needs of the growing US agriculture sector and bioeconomy.

The NIFA Division of Sustainable Bioenergy (soon to be the Division of Bioeconomy-Bioenergy-Bioproducts [B3]) supports the development of regional systems for the sustainable production of bioenergy and biobased products. An unspoken, but intended, consequence of the Sustainable Bioenergy Challenge was to create an integrated network of researchers, educators, and extension specialists who would be able to leverage the work and experience of colleagues throughout the AFRI family of related projects. The dialogue and the sharing of information that will take place here, will allow awardees to benefit from the experiences of their colleagues and yield greater opportunity for the successful completion of your projects. It is our hope that you will be able to meet new colleagues and consider new collaborations for future endeavors.

This year oral presentations will be spread throughout the meeting. Presentations will be given by Project Directors for the largest grants NIFA (or its predecessor CSREES) has ever awarded. Presentations will begin with these seven Regional Coordinated Agricultural Projects (CAPS) presenting their project overviews with representatives of their consortia available to answer your questions. We then look forward to hearing from speakers representing projects in each of our research priority areas: carbon sequestration; co-products; wildlife and pollinators; feedstock crop protection; land-use change; water; policy; and rural economic impacts, which will significantly contribute to understanding these critical aspects of the emerging regional feedstock supply chains and new conversion and distribution systems. There will also be presentation for our education grant Project Directors describing the preparation of the workforce.
needed to move to sustainable bioenergy production. The AFRI Sustainable Bioenergy Challenge is one of the largest funding centers supporting education, extension, outreach, and tech transfer within USDA.

There will be two short poster sessions and networking receptions at the end of the first two days. Our posters include new AFRI project plans from our FY2014 research grantees,

We hope that everyone who attends will benefit from the information this meeting will provide and the people you will meet.

Sincerely

The Sustainable Bioenergy (Bioeconomy-Bioenergy-Bioproducts [B3]) Division Team:
Bill Goldner, Acting Division Director
Daniel Cassidy, National Program Leader
Nancy Cavallaro, National Program Leader
Fen Hunt, National Program Leader
Ed Kaleikau, National Program Leader
Mary Purcell-Miramontes, National Program Leader
Jillian Worthen, Program Specialist

Contact us with our first initial and last name@nifa.usda.gov
SYSTEM FOR ADVANCED BIOFUELS PRODUCTION FROM WOODY BIOMASS IN THE PACIFIC NORTHWEST

Rick Gustafson, University of Washington

The overall goal of the project is to prepare the Pacific Northwest for an industry producing biobased chemicals, cellulosic ethanol, and 100% infrastructure compatible biofuels using sustainable regionally appropriate woody energy crops. This will revitalize the region’s forestry sector with establishment of a sustainable advanced biobased chemicals and biofuels industry that supports large and small growers and brings jobs to rural communities.

Project Team:

Rick Gustafson, University of Washington; Brian Stanton, GreenWood Resources; Tim Eggeman, Zeachem; Kevin Zobrist, WSU Extension; Bryan Jenkins, UC Davis; Jason Selwitz, Walla Walla Community College; Kate Field, Oregon State University.

The AHB program lays the foundation for establishment of a renewable chemicals and biofuels industry in the Pacific Northwest using poplar feedstock. The Feedstock Program demonstrates the agronomic and economic capabilities as well as the sustainable features of the hybrid poplar bioenergy cropping system as an essential component of the region’s renewable biomass supply. The Conversion Program will mitigate technology risks in the conversion processes of poplar feedstock into biobased chemicals and biofuels and validate their compatibility with existing infrastructure. The Sustainability Program integrates data from the feedstock and conversion teams to study the optimum locations for regional refineries, estimate local economic impact, perform techno-economic assessment of conversion processes, conduct life cycle assessments, and produce an integrated model for evaluating system capability. The Extension Program provides proactive bioenergy research-based information which facilitates informed decision making. Extension is the communication hub of the AHB programs, reaching out to all stakeholders, especially potential poplar feedstock growers. The Education Program is developing programs of study, curricula, work study programs, and practicums for the pre-college, community and technical college, undergraduate, and graduate education levels for a skilled workforce for the Northwest’s renewable bioenergy industry.
The US faces the urgent challenge to rapidly develop and attain a secure domestic supply of both carbon-based transportation fuels and commercially used chemicals at the scale and cost needed to compete favorably with the petrochemical industry. With established oil refining and distribution assets, a high need for military and commercial aviation fuels, and abundant woody biomass currently at scale, the Northwest US is well positioned to deliver such bio-based aviation fuels and chemicals.

Project Team:

Ralph Cavalieri, Washington State University (WSU); Michael Wolcott, WSU; Vikram Yadama, WSU; Linda Beltz, Steadfast Management; Keith Jayawickrama, Oregon State University (OSU); John Sessions, OSU; Ivan Eastin, University of Washington; Greg Johnson, Weyerhaeuser; Tomas Spink, Thomas Spink International; Paul Smith, Penn State University; Steve Hollenhorst, Western Washington University.

The project has five goals: 1) develop a sustainable biojet fuel industry in the Northwest US that uses residual woody biomass as feedstock; 2) create valuable co-products made from lignin, which is an industrial byproduct of the woody biomass to biojet process; 3) enhance and sustain rural economic development; 4) establish supply chain coalitions within the NARA region; 5) improve bioenergy literacy to develop a future energy workforce and enhance citizen understanding. The project is segmented into five teams: feedstock, conversion, systems metrics, education, and outreach.
CenUSA: AN AGRO-ECOSYSTEM APPROACH TO SUSTAINABLE BIOFUELS PRODUCTION VIA THE PYROLYSIS-BIOCHAR PLATFORM

Ken. J. Moore, Iowa State University

The North Central US is one of the most agriculturally productive areas in the world. However, intensive crop production on land within this region that is not well suited to row crop production has impaired soil and water quality and led to loss of productivity. Growing dedicated biomass crops on land that is unsuitable or marginal for row crop production would mitigate these problems and provide additional ecosystem services without adversely affecting food production. This integrated and multidisciplinary research, education and outreach project focuses on growing herbaceous perennials for fuel production that provide potentially high biomass production and ecosystem services. A regional system for producing fuels and other bio-based products from these feedstocks is being evaluated.

**Project Team** Ken. J. Moore, Iowa State University, Ames, IA 50010; Stuart. J. Birrell, Iowa State University, Ames, IA 50010; Robert C. Brown, Iowa State University, Ames, IA 50010; Mike D. Casler, USDA-ARS, Madison, WI 53706; Jill E. Euken, Iowa State University, Ames, IA 50010; H. Mark Hanna, Iowa State University, Ames, IA 50010; Dermot J. Hayes, Iowa State University, Ames, IA 50010; Jason D. Hill, University of Minnesota, Saint Paul, MN 55108; Keri L. Jacobs, Iowa State University, Ames, IA 50010; Cathy L. Kling, Iowa State University, Ames, IA 50010; Rob B. Mitchell, USDA-ARS, Lincoln, NE 68583; Pat T. Murphy, Iowa State University, Ames, IA 50010; D. Raj Raman, Iowa State University, Ames, IA 50010; Chuck V. Schwab, Iowa State University, Ames, IA 50010; Kevin J. Shinners, University of Wisconsin, Madison, WI 53707; Ken P. Vogel, USDA-ARS, Lincoln, NE 68583; Jeff J. Volenec, Purdue University, West Lafayette, IN 47907

CenUSA’s vision is to develop a regional system for producing fuels and other products from perennial grass crops grown on marginally productive land or land that is otherwise unsuitable for annual cropping. The project focuses on ten primary objectives needed to make this vision a reality: feedstock improvement; feedstock production on marginal land; feedstock logistics; modeling system performance; feedstock conversion into biofuels and other products; marketing; health and safety; education and outreach; and commercialization.
A REGIONAL PROGRAM FOR PRODUCTION OF MULTIPLE AGRICULTURAL FEEDSTOCKS AND PROCESSING TO BIOFUELS AND BIOBASED CHEMICALS
Donal Day, Louisiana State University Agricultural Center

A multidisciplinary regional consortium is addressing aspects associated with the production of energy cane and sweet sorghum and conversion to a portfolio of bio-based fuels and chemicals. This will help biofuel companies in efforts to secure sufficient carbohydrate and fiber feedstocks to meet production goals comparable with fossil-based industries and expand the feedstock base for biofuel production in the United States.

Project Team: Sustainable Bioproducts Initiative (SUBI); LSU AgCenter

This project seeks to utilize sweet sorghum and energy cane to produce butanol, gasoline, bioplastics, isoprene and by-product chemicals. We are bridging the gap that exists in the knowledge base regarding the economic feasibility and sustainability of growing and processing these energy crops. Our consortium is addressing aspects associated with conversion of energy cane and sweet sorghum into a portfolio of bio-based fuels and chemicals, to help biofuel companies in their efforts to secure sufficient carbohydrate and fiber feedstock to meet production goals. The program includes: improving agronomic production of energy crops through breeding for selected parameters, harvesting trials using modified sugarcane harvesters, utilizing a pilot facility to process feedstocks into fermentable sugar syrups, for industrial partners to test for production of fuels and products. Supplying input for economic models addressing agricultural and processing and cost structures for feedstock -bioproduct possibilities. Initiating training programs for future biofuels workers and extending information to extension units in multi-state areas.
Almost half of the nation’s supply of advanced biofuels, as mandated by the renewable fuels standard, will be met with the lignocellulosic resources of the southeast. While producing roughly 10 billion gallons of alternative fuels is well within the region’s capacity, a considered and thoughtful transition is needed to insure a sustainable supply of biomass for this new industry. With more than 30 million acres of southern pine plantations distributed throughout the South, an expansive biomass source for fuels production is in place. New energy crops are needed to supplement the existing resource and provide an affordable and reliable supply of feedstock optimized for today’s conversion technologies.

**Project Team:** Tim Rials, University of Tennessee; Steve Kelley, NC State University; Steve Taylor, Auburn University; Bill Hubbard, University of Georgia; Mike Cunningham, ArborGen, Inc.

Working closely with conversion technology collaborators, The Southeastern Partnership for Integrated Biomass Supply Systems is developing today’s forest resources for near-term progress while advancing energy crop supply systems optimized for infrastructure-compatible fuels production. The program’s overarching goals are to:

1. Demonstrate implementable ‘real-world’ solutions to the economic and environmental barriers that limit sustainable and reliable biofuels production.
2. Introduce new tools and metrics for effective decision-making in site selection and regional deployment of biofuels production from lignocellulosic biomass.
3. Provide credible, impactful, and integrated education, extension and outreach (E2O) programs that train the workforce needed, and inform stakeholders and policy makers with the knowledge necessary to thoughtfully enable the southeast’s biofuels industry.
Driven by the broad societal benefits that sustainable bioenergy value chains could provide, NEWBio aims to overcome existing barriers and dramatically increase the sustainable, cost-effective supply of lignocellulosic biomass while reducing net greenhouse gas (GHG) emissions, enhancing ecosystem services, and building vibrant communities in the Northeast United States.

**Project Team**: Richard, Tom, Penn State, Project Director; Volk, Timothy, SUNY ESF, Associate Project Director; Kinne, Barbara, Penn State, Project Manager; Bonos, Stacy, Rutgers University, Co-PI; Cafferty, Kara, Idaho Nat’l Lab, Co-PI; Ciolkosz, Daniel, Penn State, Co-PI; DeVallance, David, West Virginia University, Co-PI; Jacobson, Michael, Penn State, Co-PI; Kalavacharla, Venugopal, Delaware State, Co-PI; Kemanian, Armen, Penn State, Co-PI; Langholtz, Matthew, Oak Ridge Nat’l Lab, Co-PI; Leahy, Jessica, University of Maine, Co-PI; Lindenfeld, Laura, University of Maine, Co-PI; Marrison, David, Ohio State, Co-PI; Murphy, Dennis, Penn State, Co-PI; Selfa, Theresa, Penn State, Co-PI; Smart, Lawrence, Cornell University, Co-PI; Spatari, Sabrina, Drexel University, Co-PI; Wang, Jingxin, West Virginia University, Co-PI

The Northeast has substantial demand for transportation fuels, an educated and capable rural workforce, and over 3 million acres of marginal, degraded and abandoned land that could become productive, profitable sources of biomass with improved management. Under-utilized agricultural land that can be used to grow short-rotation woody crops and perennial grasses can play important, complementary, co-evolving roles in creating a sustainable, reliable, and affordable feedstock supply for biofuels, bioenergy, and biomaterials production for the region. The NorthEast Woody/warm-season BIOmass (NEWBio) Consortium is designing, implementing, analyzing, and evaluating robust, scalable, and sustainable value chains for biomass feedstocks from New England to the West Virginia. NEWBio is a unique collaborative network of public and private universities, businesses, non-profit organizations, and government agencies organized around a set of four large-scale demonstration sites, each forming the basis of a 500 to 1200 ton/day supply chain of lignocellulosic biomass suitable for advanced transportation fuels. Each demonstration is stakeholder driven, with commercial collaborators committed to feedstock production, logistics, preprocessing and conversion. These demonstration sites will provide a real-world focus for our team's research, extension, and educational efforts in three technical thrusts: human systems; plant production and genetics; harvest, preprocessing, and logistics; with four integrating themes: sustainability systems; safety and health; extension; education; and leadership. Through an intensive program of stakeholder engagement NEWBio will 1) provide the scientific and practical knowledge needed to overcome current barriers, 2) educate the entrepreneurs, employees, and citizens who will translate that knowledge into action, and 3) realize a sustainable bioenergy future.
Bark beetle infestations have generated large amounts of dead wood in pine and spruce forests across the US Mountain West in recent years. Removal of this wood is a priority for forest restoration and fire hazard reduction in many areas, but mitigation treatments are costly and the resulting biomass often must be piled and burned with negative repercussions for local air quality. The BANR project investigates the technological, economic, environmental, and social feasibility and sustainability of using this material as a feedstock for small-scale thermochemical conversion to drop-in liquid biofuels and a biochar agricultural product.

Infestations of pine and spruce bark beetles have caused widespread mortality in coniferous forests in the Rocky Mountains over the past decade, with ~42 million acres of U.S. forests affected. Large amounts of biomass are currently being removed for forest restoration and fire hazard reduction but there is limited use of this wood for conventional products and open pile burning as a means of disposal is widespread. Our project is developing a comprehensive program to address the major challenges limiting feedstock development, production, logistics and utilization of insect-killed trees as a resource for production of sustainable biofuels and bioproducts. Ongoing research includes creating a spatial atlas of wood availability, advancing the logistics of harvest and preprocessing, exploring issues of quality with respect to thermochemical conversion, undertaking comprehensive economic, environmental, and social/policy assessment, and integrate research results into life cycle analyses and detailed supply chain models.
COPRODUCTION OF GLUCONIC ACID AND ISOBUTANOL FROM CELLULOSIC BIOMASS
Zhiliang (Julia) Fan, University of California Davis

Starting from cellulosic feedstock, the conventional gluconic acid and isobutanol production process involves five steps: pretreatment, cellulase production, enzymatic hydrolysis to make sugars, aerobic fermentation to produce gluconic acid from cellulose hydrolysate, and anaerobic fermentation to produce isobutanol from sugars. Cellulase production or purchase represents a substantial portion of processing costs. In this proposed route, cellulase production, enzymatic hydrolysis, and aerobic fermentation will be consolidated into a single step—producing cellooligosaccharide aldonates (COAs) from pretreated cellulose by an engineered cellulolytic fungus in an aerobic fermentation step—and isobutanol and gluconate will be produced from COAs in a subsequent anaerobic fermentation step. Hence, the proposed process has only three steps: pretreatment, aerobic fermentation, and anaerobic fermentation. Compared to the conventional process, the proposed process is more consolidated and requires neither a dedicated process for cellulase production nor the exogenous addition of cellulase, both of which will result in lower processing costs.

Project Team: Zhiliang (Julia) Fan (Bio & Ag Engineering, UC Davis); Takao Kasuga (Plant pathology, UC Davis & USDA-ARS); Shota Atsumi (Chemistry, UC Davis); Charles Wyman (Chemical Engineering, UC Riverside)

The overall goal of this project is to develop the new route for co-production of isobutanol and gluconate using poplar as the feedstock. The project goal will be addressed via the following objectives: (1) construction and characterization of the engineered Neurospora crassa strains; (2) construction and characterization of the engineered Escherichia coli strains; (3) development of an aerobic fermentation process for producing calcium oligosaccharide aldonates; and (4) development of an anaerobic fermentation process for producing isobutanol and gluconate.
It has been extremely difficult to discriminate between the chemically non-equivalent cellulose hydroxyl groups because of the heavily hydrogen-bonded, insoluble nature of cellulose. Because of its intractability, forcing conditions (strong catalysts like NaOH or H₂SO₄, high temperatures, long reaction times) have been necessary to derivatize cellulose, making selectivity (“regioselectivity”) very difficult to achieve. Yet from the few cellulose derivatives that have been laboriously, regioselectively synthesized, we know that essentially all properties tested have strong dependence on where cellulose is substituted. Our goal is to develop new methods for regioselective synthesis of polysaccharide derivatives that overcome these difficulties and show the enhanced properties that are achievable by controlling substitution regiochemistry, thus paving the way to new, useful renewable materials.

**Project Team:** Kevin Edgar, Virginia Tech, PD; Charles Buchanan, Eastman Chemical; Petra Mischnick, Braunschweig University

We are developing new methods for regioselective synthesis of polysaccharide derivatives and using those methods to make novel materials, and establish their analytical characteristics and structure-property relationships. We have succeeded so far in providing access to cellulose ester regioselectively substituted derivative families that were never before accessible, discovered two new and practical reactions for synthesis of important regioselectively substituted cellulose derivatives, and established a new protecting group for regioselective polysaccharide derivative synthesis.
ENGINEERING HIGH VALUE OIL PRODUCTION INTO BIOFUEL CROPS

Zuodong Jiang, Chase Kempinski and Joe Chappell

Plant Biology Program and Department of Pharmaceutical Sciences, University of Kentucky, 789 S. Limestone, Lexington, KY 40536-0596

Assuming biofuels generated via the fermentation of sugars derived from cellulosic and non-cellulosic constituents of biofuels crops is providing a substantial contribution to our future energy needs, augmenting and amending the productivity of these biofuel crops is now a major research thrust worldwide. One way of enhancing these biofuels crops will be to engineer them for additional value-added components such as oils, that can be used for efficient fuel production and the manufacturing of other high-value products currently derived from petroleum oils. Towards this end, we are engineering optimized production of long, branched-chain hydrocarbon biosynthesis into plants suitable as biofuels crops. Branched chain hydrocarbons, like methylated triterpenes, are readily cracked into paraffins and naphthenes that can either be distilled to combustible fuels (gasoline, jet fuel and diesel), or can be used directly for the synthesis of plastics, nylons, paints and other oil-derived products manufactured by diverse chemical industries.

To create a production capacity for specific terpenes of industrial interest, we have pioneered the development of strategies for diverting carbon flow from the native terpene biosynthetic pathways operating in the cytosol and plastid compartments of plants for the generation of specific classes of terpenes. In the current work, we have demonstrated how difficult it is to divert the 5-carbon intermediates DMAPP and IPP from the mevalonate pathway operating in the cytoplasm for triterpene biosynthesis, yet diversion of the same intermediates from the methylerythritol phosphate pathway operating in the plastid compartment leads to the accumulation of very high levels of the triterpenes squalene and botryococcene. This was assessed by the co-expression of an avian farnesyl diphosphate synthase plus a yeast squalene synthase, or a chimeric botryococcene synthase from the algae Botryococcus braunii. The successful targeting of triterpene biosynthesis to the chloroplast has also been extended by the introduction of plastid-targeted triterpene methyltransferases, resulting in the efficient conversion of triterpenes to their methylated forms. Field performance of these plant lines is currently being evaluated.

Because the bulk of our engineering work has been done exclusively with tobacco, a dicotyledenous species, another objective has been to apply our engineering approach to monocotyledenous species, which offer additional benefits to large-scale production platforms. Significant progress in engineering triterpene metabolism in Brachypodium distachyon has been achieved and will be presented. Lastly, we have been exploring engineering triterpene accumulation into different plant tissues with eye towards alternative harvesting and extraction technologies. For this reason, progress in installing this metabolism into seeds will also be presented.
Lactic acid is used worldwide in medicines, foods, and as a renewable chemical feedstock to replace petrochemicals in many applications. Production of optically pure acid is generally achieved via fermentation of dextrose-containing substrates by highly efficient bacteria, yeasts, or fungi. Because undissociated acid is more easily extracted from the fermentation broth than salt forms, the profitability of lactate fermentation is directly related to the pH at which these reactions are carried out. *L. casei* is an aciduric bacterium that produces L-lactic acid as the major end-product of carbohydrate fermentation. This project will leverage our knowledge of *L. casei* systems biology to develop strains that produce L-lactic acid from spent algae used in the production of biodiesel, and from carbohydrates such as xylose and cellubiose present in glucose-depleted switchgrass hydrolysates. Our research will produce fundamental knowledge of factors that determine L-lactic acid production by *L. casei* from algae- and lignocellulosic-based process streams, and generate strains suitable for the conversion of low-value waste materials into high-value L-lactic acid. These outcomes will support industry efforts to establish profitable coproducts that help bridge the path to full-scale advanced biofuels production.

**Project Team:** Dr. Jeff R. Broadbent, Utah State University, Logan; Dr. James L. Steele, University of Wisconsin, Madison

The overall goals of this project are to develop strains of *Lactobacillus casei* tailored for lactic acid fermentation at low pH of low-value substrates derived from algae and switchgrass feedstocks after biofuels production. To achieve our goals, we are employing a combination of traditional microbiology methods and systems biology approaches (i.e., genomics, transcriptomics, metabolomics, and metabolic flux analysis), to complete three objectives: 1. Identify and optimize conditions for lactic fermentation of algal carcasses by *L. casei*; 2. Develop *L. casei* strains for fermentation of glucose-depleted switchgrass hydrolysates to L-lactic acid; and 3. Identify strategies to optimize lactic acid fermentation of algal carcasses and glucose-depleted switchgrass hydrolysates by *L. casei* at low pH.
LANDSCAPE STRUCTURE AND NATURAL PEST-SUPPRESSION SERVICES IN BIOENERGY LANDSCAPES: IMPLICATIONS FOR REGIONAL FOOD AND FUEL PRODUCTION

Dr. Claudio Gratton, University of Wisconsin

Policies, economics and societal demand will inevitably drive an increase in the proportion of agricultural and non-agricultural land devoted to bioenergy. These rapid changes will alter the amount and spatial configuration of land-use and land-cover types in the landscape. Theoretical and empirical work suggests that changes in the structure of the agricultural landscape will affect crop yield through indirect effects on natural enemies and crop pests. Despite the importance of this hypothesis to both conventional food and bioenergy-based agriculture, this hypothesis remains to be rigorously tested.

Project Team: Claudio Gratton (PD) / University of Wisconsin, Entomology; Tim Meehan (coPD) / University of Wisconsin, Entomology and Great Lakes Bioenergy Research Center; Chris Kucharik (coPD) / University of Wisconsin, Agronomy; Phil Townsend (coPD) / University of Wisconsin, Forest and Wildlife Ecology

Focusing on soybean-based biofuel, its principle pest (soybean aphid) and its natural enemies (generalist predators such as ladybeetles) across a 19-county region of southern Wisconsin, we will use empirical (Obj. 1) and biophysical crop modeling (Obj. 2) to evaluate the role of landscape structure on biofuel yield through the indirect effects on natural enemies and pests. We will further develop remote-sensing approaches to expand our predictions of biofuel yield and the effect of biocontrol services to the scale of the regional landscape (Obj. 3). By merging of these interdisciplinary approaches to address complex issues of species interactions at broad scales, we will generate forecast maps that can help evaluate how ecosystem services such as biocontrol and crop yield trade off at the landscape scale thereby making the outcomes of this proposal relevant to land managers and policy makers (Obj. 4).
MANAGING INSECT PESTS IN THE MULTI-USE LANDSCAPES OF BIOENERGY AND
CONVENTIONAL CROPPING SYSTEMS IN THE GULF COAST
Lloyd T. (Ted) Wilson Texas A&M AgriLife Research

Insect and disease pests are major constraints to the economic production of rice, sugarcane, and sorghum in the U.S. Gulf Coast region. However, insect and disease management programs have not been developed for bioenergy crops. While there is a general perception that bioenergy crops are “immune” to pests and can be produced with minimal inputs, our research shows that this is not the case. Although energy canes differ by degree in their sensitivity to insect and disease pests, our previous research suggests it is very unlikely that cultivars will be found with across the board high levels of resistance. Our proposal addresses the Program Area priority Crop Protection for Sustainable Feedstock Production Systems (A6121) and will improve the field and regional management, and both economic and environmental sustainability of the most damaging insects and diseases of energy cane and high biomass sorghum grown on the Gulf Coast. This project will help stakeholders implement a suite of diversified pest management tactics at a regional scale, which will reduce dependence on fossil fuels while keeping American agriculture competitive.

Project Team: Thomas E. (Gene) Reagan/ Louisiana State University Agricultural Center; Yubin Yang/ Texas A&M AgriLife Research; Lloyd T. (Ted) Wilson/ Texas A&M AgriLife Research; Julien Beuzelin/ Louisiana State University Agricultural Center; Jeff W. Hoy/ Louisiana State University Agricultural Center; Blake Wilson/ Louisiana State University Agricultural Center; Matt VanWeelden/ Louisiana State University Agricultural Center; M. O. (Mo) Way/ Texas A&M AgriLife Research; Allan T. Showler/ USDA-ARS Kerrville, TX 78028

The overall goal of this research is to build a landscape-wide pest management program that will mitigate insect pest and disease pressures and damage to bioenergy crops in interaction with conventional crops in the U.S. Gulf Coast region. Critical data on the biological, ecological, and economic impact of major pests and diseases is being obtained through our research. Program activities include landscape-wide plant and pest phenological surveys, multi-crop field and greenhouse bionomics experiments, and pest density/yield response studies. The results are being integrated into an analysis and forecast system to provide the capability to identify optimal pest management strategies. By enhancing bioenergy and conventional cropping system compatibility, the program will help achieve goals of the Energy Independence and Security Act of 2007.
Deployment of grass-based bioenergy systems requires public and grower support for introduction of novel perennial grass crops into landscapes currently dominated by annual grain and food crops, some closely related to the new bioenergy species. In these landscapes, there is substantial potential for generalist insect pests to move among bioenergy and food crops and to cause damage by herbivory and virus transmission. Juxtaposition of annual and perennial crops may intensify pest and disease problems because pests amplified in annual crops may find long-term refuge in perennial hosts. Alternatively, perennial habitats may support larger populations of natural enemies and increase biocontrol services.


**Brief Summary of Project:** Deployment of perennial grass-based bioenergy systems offers transformational opportunities for American agriculture. However, perennial grass cropping systems may also accumulate insects and pathogens that damage other crops. This risk may be exacerbated by trade-offs in selection of grasses for biofuel-valued traits (fast growth, low lignin) at the cost of natural defenses. Alternatively, new biofuel crops have potential to reduce pest losses at landscape scales if cultivars are well-screened and pest-suppressive cropping strategies are deployed. To develop strategies to mitigate crop risks and enhance benefits, we are examining three groups of highly mobile, grass-associated pests: cereal aphids, aphid-vectored viruses, and introduced beetles with root-feeding white grub larvae. These pests represent key above- and belowground threats with strong potential to accumulate in perennial grasses and spillover to other crops. We are conducting an integrated set of laboratory and field experiments to (1) Evaluate pest response to bioenergy-selected traits in multiple switchgrass (*Panicum virgatum*) cultivars; (2) Quantify relative importance of crop traits, species composition, landscape factors, and management in determining pest accumulation and exchange; and (3) Develop landscape-specific management strategies to limit pest exchange among bioenergy grasses and other crops.
A shift in agricultural landscapes towards increasing acres devoted to biofuel crops is likely to affect the roles and impacts of pest and beneficial arthropods. The replacement of some habitats with intensively managed biofuel crops will change the available resources for pollinators and natural enemies, thus potentially impacting the overall health of these populations and the ecosystem services they provide. Sustainable production will require an understanding of how insertion of major novel crops (e.g., perennial grasses) or large-scale plantings of known crops (e.g., winter canola), into the mosaic of extant crops and natural habitats will affect the ecosystem services provided by beneficial species, as well as the detrimental effects caused by pest species. Sustainability will be affected if the scale or proximity of a biofuel crop habitat results in losses caused by pest pressures or pesticide use increases economic and environmental costs (e.g., beneficial insect losses). Our research addresses an important Program Area Priority: Evaluate and mitigate the challenges that large-scale production of a biofuel crop will have on crop pest pressures as well as beneficial species, such as natural enemies and pollinators. We are evaluating the impact of a first-generation biofuel crop (winter canola) that is rapidly increasing in acreage throughout the Southern Great Plains, and has produced significant, unexpected changes in arthropod dynamics. We have initiated similar studies in switchgrass, a second-generation, perennial, biofuel crop that is only beginning to be planted on a landscape scale.

**Project Team:** Timothy Kring, University of Arkansas; Robert Wiedenmann, University of Arkansas; Kristopher Giles, Oklahoma State University; Kristen Baum, Oklahoma State University; Brian McCornack, Kansas State University; James Hagler, USDA-ARS

Expansive monocultures of biofuel crops may serve as a nursery producing pests and/or beneficial arthropods (source), or may attract or trap these organisms (sink). These source/sink relationships may be beneficial or deleterious to the feedstock crop or to the surrounding agricultural landscapes. Our research is addressing aspects of source/sink relationships in a first-generation biofuel crop (canola) and a second-generation biofuel crop (switchgrass) by: 1.) identifying the arthropods using the energy crop, 2.) evaluating the importance of beneficial organisms maintaining pest control in the energy crop, and 3.) determining the extent and timing of movement of the important pest and beneficial species among the energy and proximal agricultural crops. This research is advancing our knowledge of risks and benefits from placing large biofuel crop monocultures into established agricultural landscapes.
THE ROLE OF DIVERSIFIED BIOENERGY CROPPING SYSTEMS IN ENHANCING BIOLOGICAL CONTROL OF THE SOYBEAN APHID
Gregg Johnson, University of Minnesota

The development of production systems and landscapes organized around optimizing a combination of food, bioproducts, and ecosystem services is critical for the long-term viability of agriculture. The studies proposed here will focus on the sustainable integration of diversified perennial-based cropping systems that not only supply feedstock for bioenergy applications, but also provide numerous ecosystem services, including those that offer crop protection for other bioenergy crops such as soybean. The soybean aphid, *Aphis glycines*, has spread throughout the soybean growing areas in North America and is causing both economic and environmental damage through lost yield and the need for insecticide use. Our proposal aims to combine the benefits of sustainable bioenergy production with tangible ecosystem services, specifically biological control of the soybean aphid. These dual benefits should spur increased adoption of sustainable production of raw material in support of biomaterials and bioenergy sectors in the U.S.

**Project Team:** Gregg Johnson (Department of Agronomy and Plant Genetics, UofMN); George Heimpel (Department of Entomology, UofMN); Craig Sheaffer (Department of Agronomy and Plant Genetics, UofMN); David Tilman (Department of Ecology, UofMN); Donald Wyse (Department of Agronomy and Plant Genetics – UofMn); James Eckberg (Graduate Student – Department of Agronomy and Plant Genetics – UofMn); Julie Peterson (Post-Doc – Department of Entomology, UofMN)

Economic and environmental concerns with current annual-based crop production systems has lead to a call for the development of production systems and landscapes organized around optimizing a combination of food, bioproducts, and ecosystem services. We will focus on the sustainable integration of diversified perennial-based cropping systems that supply feedstock for bioenergy and bioproducts as well as offer ecosystem services including those that offer crop protection for other crops such as soybean. Our goal is to 1) develop an agronomically-realistic platform for the production of perennial bioenergy crops, and 2) support a knowledge-based strategy for integration of bioenergy cropping systems in a way that supports ecosystem services that lead to reduced pest pressures in surrounding crops. The ecosystem service that we are targeting is biological control of the soybean aphid, a devastating invasive pest. We will focus on four bioenergy cropping systems; a polyculture mix comprising forbs, legumes, and tall grass prairie species, a monoculture of willow, a mix of willow and herbaceous polyculture crops in an alley cropping configuration and a monoculture of soybean that will serve as the control. The study emphasizes two main objectives. First, we will compare crop growth and productivity of the various bioenergy cropping systems. This information will be used to estimate net energy balance and biomass conversion rates. Second, we will compare biological control of soybean aphid adjacent to three classes of bioenergy plantings and the control site. This will be done using a combination of sampling to determine the abundance of soybean aphids and their natural
enemies, determinations of the extent of resource use in the biofuel plantings, and estimation of a biocontrol services index, which defines the contribution of surrounding landscapes to biological control. The biological control objective will also include releases of approved, exotic parasitoids of the soybean aphid. An understanding of the implications of diversified multi-species bioenergy cropping systems in the context of providing crop protection and ecosystem services benefits is critical to the long-term sustainability of multi-use landscapes. This research will provide information that will help make decisions on biomass cropping systems design, placement, and potential scale of influence as it relates to the surrounding landscape. We will conduct workshops through a partnership with the University of Minnesota’s Institute on the Environment to provide information to farmers, landowners, lawyers, business professionals and policy experts that will lead to more effective planning as it relates to the long-term sustainability of agricultural systems in the future.
EVALUATING THE SUSTAINABILITY OF BIOENERGY PRODUCTION IN THE SOUTHEAST ON THE BASIS OF WILDLIFE AND POLLINATOR RESPONSES ACROSS SPATIAL SCALES

Dr. Robert Fletcher, University of Florida

The Southeast is considered to be a major contributor for future bioenergy production. Several bioenergy feedstocks are being considered in the Southeast, but much of the potential comes from forest biomass, in part because the Southeast holds over 200 million acres of managed pine forests. Nonetheless, the effects that expansion of biofuels will have on biodiversity are largely unknown. We are testing for the ecological impacts of ethanol production using corn (Zea mays) and three major sources of woody biomass identified by the DOE’s Billion-Ton Report including the removal of logging residues from clear cuts, plantation thinning, and conversion of conventional timber production to densely-planted, short-rotation “energy plantations”.

**Project Team:** Dr. Robert Fletcher / University of Florida; Dr. Berry Brosi, / Emory University; Dr. Holly Ober, / University of Florida; Dr. Lora Smith, / Joseph W. Jones Ecological Research Center

This project aims to understand effects of land-use change from an increase in bioenergy production on wildlife and pollinators, including habitat fragmentation and edge effects on breeding species, and develop best-management practices for the Southeast region. We are quantifying species responses from several taxa (bees, reptiles, birds, and bats) to three major pathways for extracting biomass from pine forest—residue removal, forest thinning, and the use of dedicated, short-rotation stands of pine—and we are contrasting these land uses to corn fields (first-generation biofuels land use) and old-growth forest reference conditions. Our approach allows direct, standardized comparison of species responses to these different pathways. These responses will provide specific guidance to the development of within-stand, best management practices, insight on effective indicators for sustainable biofuels production, and will be integrated into a multi-scale model aimed to interpret large-scale effects and tradeoffs that may occur across regions. To achieve these ambitious objectives, we are partnering with other scientists and industry that have ongoing biofuels projects in the region. We have begun quantifying species responses to these land-uses in Alabama, Georgia, and northern Florida, and will continue further sampling in the upcoming year. Our project will conclude with extension activities to make information available regarding sustainable bioenergy production.
PROMOTING POLLINATORS THROUGH BIO-OIL PRODUCTION
Frank Forcella, United States Department of Agriculture Agricultural Research Service

Many alternative oilseed crops produce abundant pollen and nectar and, accordingly, attract many insects, especially in comparison to standard commodity crops such as corn, soybean, and wheat. Several alternative oilseeds are adapted to the Upper Midwest and Northern Great Plains, where most of the nation’s transient honey bees originate, and where a pollinator foraging crisis currently exists. These alternative oilseed crops can alleviate this crisis and simultaneously rival economic returns generated by corn and soybean for the region’s growers.

Project Team: Frank Forcella, USDA-ARS, Morris; Russ Gesch, USDA-ARS, Morris; Sharon Weyers, USDA-ARS, Morris; Jane Johnson, USDA-ARS, Morris; Jon Lundgren, USDA-ARS, Brookings; Sharon Papiernik, USDA-ARS, Brookings; Walter Riedell, USDA-ARS, Brookings; Shannon Osborne, USDA-ARS, Brookings

Simplified agroecosystems have diminished habitats for beneficial insects throughout the Midwest and Northern Great Plains. Recent national emphasis on increasing biofuel production affords producers the opportunity to reintegrate critical resources for beneficial insects into landscapes that were homogenized by modern corn-soybean rotations. Several flower-rich and pollinator-friendly oilseed crops comprise this opportunity. However, balancing constraints of profitable farm production against practices that maximize benefits of integrating oilseed crops into traditional rotations is challenging. Our proposed research designs and tests best management practices for economically and agriculturally rational biofuel crop rotations appropriate for northern states. Management practices are optimized based on their effects on profitability and beneficial insects. This project diversifies the range of bio-oil crops available for producers and simultaneously enhances environmental quality for beneficial insects. Specifically, the project (i) integrates a suite of high-value oilseed crops, selected based on the timing of their production of flowers (food resources) from April to November, into rotations involving traditional crops (corn, soybean, wheat) and examine their profitability; (ii) identifies the diversity and relative abundance of pollinator communities that are associated with each rotation and examines the effects of diversification on pollinator health; and (iii) documents spillover effects produced by diverse rotations on natural enemies of pests in adjacent bioenergy crops.
As energy needs continue to grow for the United States the ability to use alternative energy sources through the use of sustainable biomass feedstocks becomes more important. Identification of a native plant that can efficiently and effectively produce biomass feedstocks, yet maintain some ecological integrity is preferred. Switchgrass is a native warm-season North American grass that may fit this role because it can provide habitat for some grassland bird and pollinator species for at least part of their lives. Most switchgrass biomass studies examining avian responses have documented only relative abundance and species richness, whereas we documented reproductive parameters such as nest success and fledgling rates. Also, there are few studies examining the use of switchgrass biofuel field by pollinator species. Thus, we developed the first-ever data on the impact of switchgrass production on multiple grassland bird species’ fecundity at the field, matrix, and regional scales. Additionally, we collected information about pollinator species richness and abundance at switchgrass production fields.

**Project Team:** Center for Native Grassland Management; The University of Tennessee-Knoxville; Christopher M. Lituma, Patrick D. Keyser, Elizabeth D. Holcomb, Charles Kwit, Joseph D. Clark

Currently, there is little research that explores how avian density, avian breeding success, and pollinator communities potentially differ between switchgrass biomass feedstock fields, and more typical reference fields. We developed a research project to explicitly address these needs and glaring scientific information gaps. We designed and are currently implementing a project to collect data about bird densities in switchgrass biomass feedstock fields and reference fields. We are also searching for priority grassland bird species’ nests in order to determine if there are differences in nest success between field types. Additionally, we are collecting pollinator species, primarily bees, to determine if there are differences in pollinator communities between the field types. This is pioneering research and the data collected will help to inform future ecological impacts of biomass feedstock field plantings.
UNDERSTANDING PLANT-SOIL-MICROBIAL PROCESSES TO ENHANCE SOIL CARBON SEQUESTRATION.

Gail Wilson, Oklahoma State University

Results of this study will inform plant breeders on belowground characteristics that may improve soil tilth, decrease fertilizer inputs and increase soil carbon sequestration, all without a loss in production.

**Project Team:** Gail Wilson/ Oklahoma State University, R. Michael Miller/Argonne National Laboratory, Nancy Johnson/ Northern Arizona University, Yanqi Wu/ Oklahoma State University

Switchgrass shows great promise as a native, low-input biofuel feedstock. Cultivar development has focused primarily on aboveground biomass production. Our proposed research program extends belowground and consider how switchgrass interactions with soil microorganisms influence soil carbon dynamics and the potential for carbon sequestration. Sustainability of feedstock production practices may be improved if breeders can better identify switchgrass traits that reduce fertilizer inputs and increase the crop’s ability to sequester carbon in recalcitrant pools. These goals may be reached through a better understanding of mycorrhizal symbioses. Our current work indicates that genetic and environmental factors control the development and functioning of mycorrhizal symbioses in switchgrass. Increases in arbuscular mycorrhizal (AM) colonization of switchgrass roots and increases in the density of AM hyphae in the soil are predicted to enhance both the stabilization of soil structure and the accumulation of soil organic carbon. The mechanism for this association is based not only on the growth and physical entanglement mechanism of mycorrhizal fungal hyphae, but also the recalcitrant nature of mycorrhial hyphae. Consequently, better management of AM symbioses may improve our ability to generate long-term carbon storage in soils under biofuel feedstock management. The overall objective of our research program is to simultaneously maximize the above- and belowground benefits of mycorrhizal symbioses by selecting cultivars that most effectively utilize mycorrhizal fungi to increase nutrient and water use efficiency and also increase soil C storage.
AT THE ROOT OF SUSTAINABLE BIOENERGY PRODUCTION: USING GENETIC VARIATION IN ROOT TRAITS TO MAXIMIZE SOIL CARBON SEQUESTRATION AND BIOMASS YIELDS.

Marie-Anne de Graaff, Department of Biological Sciences, Boise State University,

Land-use change for bioenergy production can create greenhouse gas (GHG) emissions through disturbance of soil carbon (C) pools, but native species with extensive root systems can rapidly repay the GHG debt, particularly when grown in diverse mixtures, by enhancing soil C sequestration upon land-use change. Native bioenergy candidate species, switchgrass (Panicum virgatum L.) and big bluestem (Andropogon gerardii) show extensive within-species variation, and our preliminary data show that increased cultivar diversity can enhance yield. With this project we wish to assess: (1) how shifting C3-dominated nonnative perennial grasslands to C4-dominated native perennial grasslands for use as bioenergy feedstock affects soil C sequestration; (2) how within-species biodiversity in native grassland feedstock affects the efficiency of nutrient use and C sequestration; and (3) whether energy gain resulting from an increase in soil C storage and yield, along with a decrease in nutrient inputs and losses in low-input diverse mixtures of perennial grasses, is sufficient to offset energy gain from relatively greater biomass production in high input monocultures of perennial grasses. Our experiment is conducted at the Fermilab National Environmental Research Park that compares different approaches for perennial feedstock production ranging across a biodiversity gradient, where diversity is manipulated at both the species- and cultivar level, and nitrogen (N) is applied at two levels (0 and 67 kg/ha). Ultimately the goal of our project is to evaluate which method of land-use change for bioenergy production maximizes yields, while minimizing the negative impacts of land-use change on the environment.

Project Team: Marie-Anne de Graaff - Department of Biological Sciences, Boise State University, Boise, ID 83725; Geoff Morris - Department of Agronomy, Kansas State University, Manhattan KS, 66506; Julie Jastrow - Biosciences Division, Argonne National Laboratory, Argonne, IL 60439; Johan Six - Institute of Agricultural Sciences, ETH, Zurich, Switzerland

Land-use change for bioenergy production can create greenhouse gas (GHG) emissions through disturbance of soil carbon (C) pools, but native species with extensive root systems may rapidly repay the GHG debt, particularly when grown in diverse mixtures, by enhancing soil C sequestration upon land-use change. Native bioenergy candidate species, switchgrass (Panicum virgatum L.) and big bluestem (Andropogon gerardii) show extensive within-species variation, and our preliminary data show that increased cultivar diversity can enhance yield. With this project we wish to assess how shifting C3-dominated nonnative perennial grasslands to C4-dominated native perennial grasslands for use as bioenergy feedstock affects soil C sequestration. Specifically we aim to evaluate whether energy gain resulting from an increase in soil C storage and yield, along with a decrease in nutrient inputs and losses in low-input diverse
mixtures of perennial grasses, is sufficient to offset energy gain from relatively greater biomass production in high input monocultures of perennial grasses. Our experiment is conducted at the Fermilab National Environmental Research Park, and compares different approaches for perennial feedstock production ranging across a biodiversity gradient, where diversity is manipulated at both the species- and cultivar level, and nitrogen (N) is applied at two levels (0 and 67 kg/ha). Preliminary results indicate that switchgrass cultivars differentially affect soil C stabilization rates, and that cultivars with greater specific root length promote plant derived soil C input. Greater rates of N fertilization and increasing species or cultivar diversity however does not increase soil C sequestration, despite positive impacts of these management strategies on yield. Ultimately the goal of our project is to evaluate which method of land-use change for bioenergy production maximizes yields, while minimizing the negative impacts of land-use change on the environment.
This project is designed to provide information for developing regional bioenergy system. The feedstocks being examined in the proposal are actively being developed for bioenergy programs in the Northern Plains and Upper Midewest. South Dakota is in a region that includes South Dakota is in a region that includes extensive corn growing areas (4.4 million acres, USDA-NASS, 2009), grass growing areas (3.8 million acres of harvested hay, USDA-NASS, 2009), has land that is marginal for food production, and has potential sources of wood based feedstocks in the Black Hills and Eastern Minnesota.

This project addresses two program area priorities. Biochar is being examined as an enhanced-value co-product that could be important for improving degraded soils within the region thus improving their utility for food or biomass production. The project addresses the priority area entitled carbon sequestration and sustainable bioenergy production. The impact of biocahr as a soil amendment on C sequestration, greenhouse gas emissions, crop productivity, and soil quality are being evaluated.


The project is intended to provide answers needed for the development of sustainable food and biomass production systems. Crude bio-oil production from biomass feedstocks using local pyrolytic processing has been proposed as an approach to increase the supply of bio-based liquid fuels. Under this approach, locally produced crude bio-oil by pyrolysis would be transported to a central refinery to produce a liquid fuel or fuel additive, such as gasoline or diesel. Objectives included the optimization of crude bio-oil production using pyrolysis processes applied to three feedstocks including switchgrass, corn stover, and woody materials and the characterization and evaluation of biochar, a by-product of bio-oil production, for its ability to rehabilitate degraded soils and improve ecological services. The hypothesis is that biochar products will have different physical and chemical properties due to feedstock source and processing parameters, which will affect their ability to rehabilitate degraded soils, sequester carbon, and alter greenhouse gas emissions. The outcomes of this project will provide information needed to optimize bio-oil production from three commonly proposed feedstocks appropriate for the Northern Great Plains and Upper Midwest, and provide information on the utility of biochar as a soil amendment for improving eroded and degraded soils.
CARBON SEQUESTRATION AND GASEOUS EMISSIONS IN PERENNIAL GRASS BIOENERGY CROPPING SYSTEMS IN THE NORTHEASTERN US

This project seeks to help define the sustainability of perennial grass bioenergy production on marginal lands in the Northeast US by characterizing crop yields, sequestration of soil carbon (C), and emissions of nitrous oxide (N₂O) and methane (CH₄). These impacts will be determined under current production practices on wetness-prone marginal soils, for which very little relevant research exists.

**Project Team:** Brian K. Richards, CathelijneR. Stoof, Cedric W. Mason, Ryan V. Crawford, Srabani Das, Julie L. Hansen, Hilary S. Mayton, Jamie L. Crawford, Tammo S. Steenhuis, M.Todd Walter, Don R. Viands. Cornell University, Ithaca NY

In 2011 we established a perennial grass strip trial on a 10-ha (16 ac) site (denoted S1; 42N 28.20', 76W 25.94') where, due to wetness of the predominant Dalton-Madalin soils, prior use over the past 50 years was limited to occasional mowing or haying. Quadruplicate ~0.4 ha strip plot treatments are switchgrass (*Panicum virgatum* v. Shawnee), switchgrass+fertilizer N, reed canarygrass+N (*Phalaris arundinaceae* v. Bellevue), and non-converted control (fallow grassland). Nitrogen loadings were 74 kgN/ha (applied April-May for reed canarygrass starting 2012; June for switchgrass starting 2013). Permanent sampling subplots (5 per strip plot) were established along natural moisture gradients, representing 80 sampling points at which biomass yield, soil characteristics, soil moisture content, emissions, and soil C are being monitored. Given the variable nature of emissions, we use an integrated approach, with monthly large chamber campaigns (n=120 chambers, operated April to November since 2012) used to compare N₂O and CH₄ emissions among treatments, while an eddy-covariance flux tower system monitors the temporal field-scale N₂O response to temperature or precipitation events. Annual tracking of soil health parameters (including aggregate stability, available water capacity, hardness, active carbon) cover pre- and post-conversion conditions. In 2012 we began similar monitoring of a second smaller site (S2) with mature switchgrass (v. Shawnee) stands planted in 2008. Three subplots were located on upslope, sideslope and bottom slope positions to capture soil drainage gradients on each of three strip plots that had preexisting N rate treatments of 0, 56 and 112 kg N/ha. Frequent S2 emission chamber campaigns (n=36 chambers) began just prior to the June 2013 N application. Proximity to and concurrence of field operations with the S1 field site suggests that responses to temperature and rainfall measured by the S1 flux tower can be used to help interpret S2 chamber trends as well. Ongoing extended and collaborative studies based on these sites (using external funding) include: sampling for arbuscular mycorrhizae, expanded analysis of soil C forms and mineralization, earthworm population response to crop and moisture regime, site hydrologic modeling, planned addition of adjacent miscanthus plots, and coordination with the NEWBio regional project.
CAN THE BIOFUEL INDUSTRY ACCESS BIOMASS FROM PRIVATE FOREST LANDOWNERS

James C. Finley, A.E. Luloff, Penn State University

Most studies on the availability of woody biomass for energy production assume private forest landowners in the United States are able and willing to provide feedstock for biofuel production and will do so because of their perceived opportunity to increase profits. Little, if any, attention has been paid to social and cultural factors that may affect landowner decisions to participate in this evolving market.

Project Team: James C. Finley, A.E. Luloff/Penn State University; Jason Gordon/ Mississippi State University; Donald Hodges, Adam Willcox, University of Tennessee

This project addresses the assumption private forest landowners in the United States are able and willing to provide feedstock for biofuel production and will do so because of their perceived opportunity to increase profits by asking three nested questions: (1) Will private forest landowners produce raw materials for wood-based biofuel production in sufficient quantities to meet their needs? (2) What are the opportunities and concerns of communities, residents, and existing wood-based industries? (3) How will communities and residents respond to these opportunities and concerns? Using these questions, a series of mixed-methods research tasks were employed to engage selected communities in five states east or congruent with the Mississippi River in a process of identifying sustainable community development opportunities. This process included key informant interviews to identify ecological, social, cultural, and political barriers associated with biomass supply; facilitated group discussions with forestland owners and the larger community to assess receptivity to the biofuels industry; a landowner survey to assess willingness to provide needed biomass for biofuel production; and a resident survey to determine interest in biofuel production.

The findings identified several factors associated with acceptance of the biofuels industry by landowners and residents, the relative importance of various forest landowner objectives, citizen attitudes, biophysical factors useful for estimating the supply of biomass to the biofuels industry; and initial community dialogues on biofuels industry and community development. Not surprising these findings varied greatly between geographic regions; however, some consistencies were identified. We provide a discussion of how findings impact policy and inform outreach programs and strategies that can help landowners make educated decisions about the use of their resources when it comes to sustainable biomass harvesting.
SOCIAL ACCEPTABILITY OF BIOENERGY IN THE U.S. SOUTH
J. Peter Brosius, Center for Integrative Conservation Research, University of Georgia

As bioenergy continues to develop in the U.S. South, it will utilize forest lands in new ways and have different effects on a number of stakeholders: forest landowners, local communities, extant industries, policymakers, investors, and others. As more types of stakeholders become involved in bioenergy, and as the general public becomes more aware of it, understanding public perceptions of, and reactions to, bioenergy development will become increasingly important. The social acceptability of bioenergy is contingent on two things: 1) how people interpret and understand the sustainability of biomass production for energy, and 2) the development of a bioenergy infrastructure. Sustainability seeks to maximize synergies and minimize trade-offs across environmental, economic, and social domains. The ways that people understand, talk about, and act (or intend to act) in relation to the sustainability of biofuels are a critical component of social acceptability. An ethnographic approach allows us to collect detailed contextual social data and to examine how different elements of sustainability are interpreted and traded-off depending on economic, environmental, social, and cultural conditions.

Our research will enhance understanding of the complexity arising from differences in opinion and diverse framings of bioenergy among numerous stakeholders. Our analysis seeks to recognize and elucidate the multiplicity of and dynamics between various stakeholders and to pay particular attention to the multi-scalar dimensions of bioenergy development. This approach enables a comprehensive and dynamic understanding of social acceptability that can guide efforts to maximize the sustainability of bioenergy development, focus attention on areas where negative impacts of bioenergy development need to be addressed, improve our ability to communicate with stakeholders, and ultimately lay critical groundwork for bioenergy development by providing a foundation for collaborative planning in bioenergy sites.

Project Team: J. Peter Brosius: Center for Integrative Conservation Research, University of Georgia, Athens, GA; John Schelhas: USDA Forest Service, Southern Research Station, Athens, GA; Sarah Hitchner: Center for Integrative Conservation Research, University of Georgia, Athens, GA

Acknowledging the inherent social complexity of bioenergy development, our ongoing research broadly analyzes social acceptability as it plays out across regional, community, and landowner scales by examining biofuels narratives, stakeholder positions, policies and structures of governance, and mechanisms and criteria for landowner decision-making in a range of contexts of industrial biofuel sites that produce different bioenergy products.

We have completed ethnographic research in three sites where bioenergy facilities have been, will be, and are currently operating: 1) Soperton, GA (site of a proposed cellulosic ethanol/aviation fuel plant formerly operated by Range Fuels and currently owned by LanzaTech); 2) Waycross, GA (site of Georgia Biomass, an operating pellet mill; and 3)
Columbus, MS (site of the world’s first commercial-scale cellulosic biocrude plant, operated by KiOR, where operations are currently suspended). We spent three months in each of these sites conducting interviews with various stakeholders (extension personnel, county and state foresters, industry representatives, forest landowners, and members of community organizations, including local development councils involved with promoting bioenergy industry), and we have also visited secondary sites with bioenergy facilities in Georgia, Louisiana, Alabama, and North Carolina. We have also conducted extensive interviews (~60) with African American forest landowners in North Carolina, South Carolina, and Alabama about their forest management practices and knowledge of and opinions about wood-based bioenergy development.

We are currently conducting data analysis using an integrative analytical framework designed to view conservation and development issues from multiple perspectives and make potential trade-offs and synergies explicit for use by stakeholders and policy-makers. The framework will view social acceptability through three lenses - values and valuation, process and governance, and power and inequality - while also addressing issues of scale and a multiplicity of stakeholders. We will compare data from our various research sites to learn how different elements of sustainability are interpreted and traded-off depending on economic, environmental, social, and cultural conditions.

We anticipate that the results of our research will highlight many interrelated factors that make bioenergy development for liquid fuels in the U.S. South a socially complex phenomenon. The results will clarify elements of social complexity that are often left out of models based on other research approaches. By analyzing this complexity with an integrative analytical framework that uses different theoretical lenses, our research will: (1) show the different value dimensions that underlie bioenergy discussion and actions, provide insights into how these are formed and change, and examine ways that discourses can drive collaboration and polarization; (2) show how the current policies shape biofuel development and determine the potential for developing governance mechanisms to assure renewability and sustainability that effectively work across stakeholder groups; and (3) highlight groups that are underrepresented in the process and identify ways to incorporate them. Our results will also be important for designing effective policies, incentives and programs, and new land use technologies. Finally, our research will provide a foundation for collaborative planning in bioenergy sites.
THE EFFECT OF EXISTING AND NOVEL POLICY OPTIONS ON THE SUSTAINABLE DEVELOPMENT OF REGIONAL BIOENERGY SYSTEMS.

Christopher S. Galik, Nicholas Institute for Environmental Policy Solutions, Duke University

The current economic and political climate presents several challenges to the development of regional bioenergy production systems. Several existing commodity and conservation payment programs face significant cuts or even elimination in the face of federal budget deficit concerns.¹ Existing policy drivers of domestic bioenergy production, whether mandates, tax credits, or tariffs, likewise face reconsideration as the role that government plays in private markets is subject to increasing debate and scrutiny.

Nationally, a removal or reframing of government policy interventions is expected to have significant effects on domestic bioenergy markets. In the Southeast, uncertainty remains regarding the effect of policy reform and the effectiveness of alternative policies for bioenergy development. Much of the region’s potential supply of biomass lies on privately-held lands. While landowner response to Soil Bank, Forest Improvement Program, and Conservation Reserve Program incentives is observable in historical tree planting data, the effectiveness of future policy interventions in encouraging private land feedstock production will depend on the structure, magnitude, and interplay of market and policy incentives. In particular, bioenergy producers will be affected by the types and magnitudes of incentives that encourage the use of biofuel or biomass-derived electricity over competing fuels. Variations in both biomass cost and supply will translate directly into variations in bioenergy cost and supply, thus having dramatic implications for the costs associated with compliance with state or federal policy. A better understanding of the most efficient ways to both provide incentives for expanding regional bioenergy systems and for facilitating the development of private markets, taking into account environmental and rural development impacts, is therefore of crucial importance.

**Project Team:** Christopher S. Galik/Nicholas Institute for Environmental Policy Solutions, Duke University; Brian C. Murray/Nicholas Institute for Environmental Policy Solutions, Duke University; Robert C. Abt/North Carolina State University; Gregory Latta/Oregon State University; Tibor Vegh/Nicholas Institute for Environmental Policy Solutions, Duke University

While extensive research exists on the performance of traditional bioenergy policy tools, less is known about how other, less-tried approaches could work. To address this critical shortcoming, we propose to assess the performance of several novel policy tools. The specific design of each tool will be developed iteratively throughout the research project, but will follow the general policy constructs below.

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1. **Regional public/private biomass supply partnerships:** Using present Department of Defense biomass project exploration efforts and the expected work under a MOU signed between the Department of the Navy and USDA as a model, this policy construct targets critical areas for biomass production while linking producers to a stable source of bioenergy demand.

2. **Regional biomass reserve program:** Taking a cue from the unique availability and distribution of feedstocks available in the Southeast and observed swings in both inventory and price, we will model the effects of instituting a Biomass Reserve Program, a counter-cyclical payment or tiered pricing program, in the region.

3. **Integrated regional renewable energy standard:** Linking implementation of the current national RFS2 to a regional RES would provide insight into the competition for feedstock to meet two separate yet related policy objectives.

Collectively, these general policy constructs allows us to incorporate the variety of constraints now facing bioenergy market development in the region. The public-private partnership construct, for example, is less dependent on direct payments but places emphasis on fostering local markets and the protection of critical landscapes. The counter-cyclical payment construct requires a source of additional funding to implement, but has the potential to minimize feedstock price and supply volatility observed in the past. A regional RES may require relatively fewer government expenditures, but would shift the burden for compliance to individual entities and may be difficult to target production to specific areas or to specific feedstocks, thus potentially affecting social, environmental, or economic objectives. Each also reflects existing partnerships, land use and feedstock distributions, and generation portfolios unique to the region.
EVALUATING POLICY INCENTIVES FOR REGIONAL BIOFUELS PRODUCTION SYSTEMS WITH A SCENARIO-BASED DECISION SUPPORT TOOL.

Gary Radloff, University of Wisconsin-Madison

In order to advance biofuel production it will take tools and policy to evaluate the trade-offs in energy, environment, economics, land use and sustainability. We propose that what is required to make policy and land-use decisions that adequately balance these tradeoffs is an easy method and approach that moves beyond single-issue decisions to one with a more holistic view of the agroecosystem. Using the best available science and models, we propose a visual tool that allows for a rapid evaluation of the outcomes of different land-use decisions with consequences for energy, biomass, income, along with other ecosystem outcomes such as water quality, biodiversity support, etc. With this tool, we hypothesize that stakeholder discussions of policy alternatives can reflect more viewpoints and reach a more nuanced use of agricultural lands.

**Project Team:** Gary Radloff, University of Wisconsin-Madison, Wisconsin Energy Institute; Tim Meehan, University of Wisconsin-Madison, Department of Entomology / Wisconsin Energy Institute; Claudio Gratton, University of Wisconsin-Madison, Department of Entomology / Wisconsin Energy Institute; Michael Ferris, University of Wisconsin-Madison, Wisconsin Institute for Discovery; Post-doc: Amin Tayyebi, University of Wisconsin-Madison, Wisconsin Energy Institute

This project aims to design computer software as a decision support tool to test out scenarios for land use change. This will allows stakeholders to evaluate existing and future public policy options to advance biofuel production and enhance ecosystem co-benefits.

We have designed and implemented a fully working version of the decision-support tool, “Smartscape.” This tool allow policymakers and land managers the ability to evaluate trade-offs with land use under alternative scenarios, such as crops switching from corn to switchgrass, and to quantify and possibly monetize the ecosystems benefits of land use change. We are working with stakeholders, currently a diverse group consisting of state and county agency personnel, NGOs, farmers and scientists, to test the tool and then to develop policy alternatives that can assist in advancing biofuel production while enhancing environmental benefits. The stakeholder group has praised the decision support tool for its visual design, relevant data and models and functionality. After the second meeting, our stakeholders provided detailed modifications to the tool that they desired and that we have now implemented in the last version (2.0). The stakeholder group also received a detailed policy evaluation of existing biofuel policy and is now providing input on future policy options.
NORTHEAST BIOENERGY AND BIOPRODUCTS EDUCATIONAL PROGRAM (BBEP): PROVIDING FACULTY WITH TRAINING, TOOLS AND IN-CLASSROOM SUPPORT

Corinne Rutzke, PhD, Cornell University

The United States Agriculture and Forestry Industries are strongly positioned to contribute to our nation’s future energy and product needs in a significant way through renewable plant resources. An important first step in building the biobased industry is providing fundamental training and resources to the educators of tomorrow’s sustainable bioenergy and bioproducts workforce.

Project Team: PD: Corinne Rutzke, PhD/Cornell University, CO-I’s: Mingxin Guo, PhD/Delaware State University; Joyce VanEck, PhD, Tiffany Fleming/Boyce Thompson Institute for Plant Research; Dennis Hall/ The Ohio State University; Larry Walker, PhD/ Cornell University; Madhumi Mitra, PhD/ University of Maryland Eastern Shore; Zywia Wojnar/ Cornell Cooperative Extension Dutchess County

The project provides professional development training for teachers through lectures, labs, tours, classroom kits and school-year follow-up support to teachers of Science, Technology, Engineering, Math and Agriculture (STEM+A) (grades 6-undergraduate level). The target audience is teachers who aspire to leadership in bioenergy and bioproducts education in their districts. The training sessions are coordinated through week-long Teaching Partner Workshops provided by 11 land grant institutions and affiliates in the northeastern US. Annually the program reaches over 90 teachers, and through these teachers, reaches over 1400 students each year. Teachers completing the program become a partner of the program and are equipped to train other teachers in their school on the program’s bioenergy and bioproducts hands-on lab activities. Teaching Partners commit to incorporating one of the program activities into their required classroom curriculum. Teaching Partners frequently report being inspired by the program content to do more back in their school and communities. A few of our teachers have gone far beyond this initial commitment, including efforts ranging from creating new biobased lab activities to share with other teachers, initiating major agricultural-focused chemistry and social studies projects in the school district, to proposing and being awarded the funds for a commercial scale combined heat and power digester in the community!
PLACE BASED OPPORTUNITIES FOR SUSTAINABLE OUTCOMES AND HIGH HOPES: POSOH

Richard Amasino, The Board of Regents of the University of Wisconsin System

Long-term goals for POSOH address two key national needs:

- The need for education models that close the achievement gap between students from majority and minority cultures (Southerland et al., 2007)
- The growing demand for a new workforce that can participate in and help to strengthen the emerging bio-economy (White & Walsh, 2008).

The POSOH model for stimulating educational change is underpinned by the hypothesis that secondary and post-secondary learners can be motivated to learn and understand fundamental matter, energy and ecosystem concepts—thus narrowing the achievement gap by:

- teaching those concepts in the opportune context of bioenergy,
- engaging learners in inquiry-based approaches to bioenergy investigations and research,
- using inquiry-based lessons that explicitly include both culturally relevant science and community ways of knowing, acknowledging the contributions of both, and
- introducing learners to the socio-environmental context of our emerging bio-economy.

Further, POSOH recognizes that a successful bio-economy will require an innovative and multi-disciplinary approach to develop sustainably, where sustainable development is defined by the World Health Commission as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Therefore, POSOH is based on the following principles:

- Our future depends on developing and generating citizen support for new approaches to attaining sustainable means for efficiently producing food, fiber and bioenergy.
- Sustainability is context specific, involving a complex interplay of socio-cultural, regional and environmental factors.
- Each culture can have distinctive ways of understanding sustainable resource management, and multi-cultural knowledge can be connected effectively to science learning.
- Our American Indian youth represent a valuable resource—often under-served as learners and under-utilized as potential scientists and workforce members in the burgeoning bio-economy.

POSOH is poised to make a significant long-range contribution to improving science education by developing a framework for integrating multidisciplinary and multicultural learning goals for teaching and learning bioenergy concepts (e.g. cycling of matter between energy-rich and energy-poor chemicals and carbon cycling, light to chemical energy transfer, interactions and interdependence in ecosystems). This framework, called the POSOH Design Framework, is being developed for use anywhere in the nation to guide the design and development of multi-culturally relevant, place-based learning resources that foster all students’ learning about bioenergy concepts.
**Project Team:** Richard Amasino (The Board of Regents of the University of Wisconsin System), Hedi Lauffer (University of Wisconsin, Madison), Cherie Thunder (College of Menominee Nation), Rebecca Edler (College of Menominee Nation), Chris Caldwell (College of Menominee Nation), John Greenler (The Board of Regents of the University of Wisconsin System), Charles (Andy) Anderson (Michigan State University).

Our project “Place-based Opportunities for Sustainable Outcomes and High-hopes” (acronym POSOH which means "hello" in the Menominee language) is a collaborative effort to build opportunities for learners to engage in bio-energy research—from sustainability to the chemistry of carbon cycles—fully integrated with indigenous knowledge. The project provides learning opportunities to develop teacher and faculty skills for teaching bio-energy concepts using place-based, culturally-relevant, and student-centered pedagogical strategies. We are creating a cross-cultural community of professionals including educators, researchers, industry and American Indian custodians of indigenous knowledge—a community with a wide range of understandings and interests in bioenergy, sustainability, and education.

The POSOH Project’s mission includes both place-based and far-reaching focus and goals. Locally, our mission is to develop community-wide and cross-institutional collaborations to develop approaches to formal and informal science education that value and infuse Indigenous contributions to scientific knowledge and culturally diverse ways of knowing into science teaching and learning. Thus, POSOH’s local goal is to transform the vision and expectations for excellence in both science education and who can contribute to and benefit from science- and bioenergy-related studies and careers. More broadly, our mission is to build and steward a transformational model for creating place-based collaborations dedicated to reaching all learners—especially those who are underrepresented in science and science education—by valuing and infusing diverse cultural ways of knowing and their contributions to scientific knowledge into science teaching and learning. Thus, POSOH’s far-reaching goal is to document and share the Project’s local experiences so that other communities can learn from and build on our experiences and innovations.
AHB BIOENERGY EDUCATION PIPELINE
Katharine G. Field and Jason Selwitz

To ensure successful development of Pacific Northwest bioenergy, alternative energy, and allied industries, we must educate students, their families and their communities about bioenergy; provide them with the skills to operate the new technologies; and give them the tools to innovate and solve future energy problems. The Advanced Hardwoods Biofuels (AHB) education initiative is a collaborative effort between Oregon State University and the Agriculture Center of Excellence at Walla Walla Community College. We have developed a comprehensive Bioenergy Education Pipeline that includes family and community programming, K-12 curriculum development and teacher training, a bioenergy College Transition program, community and technical college workforce development, interdisciplinary, research-based undergraduate bioenergy programs, and graduate-level programs.

THE NORTHEAST WOODY/WARM-SEASON BIOMASS CONSORTIUM
Tom Richard¹, Tim Volk², Larry Smart³, Jingxin Wang⁴, Barbara Kinne¹, Kwesi Boateng⁵, Stacy Bonos⁶, Kara Cafferty⁷, Dan Ciolkosz¹,Susan Hawkins⁸, Michael Jacobson¹, Venu Kalavacherla⁹, Armen Kemanian¹, Matt Langholtz¹⁰, Dave Marrison¹¹, Dennis Murphy¹, Theresa Selfa², Sabrina Spatari¹² ¹Penn State University, ²SUNY ESF, ³Cornell University, ⁴West Virginia University, ⁵USDA ARS ERRC, ⁶Rutgers University, ⁷DOE Idaho National Laboratory, ⁸University of Vermont ⁹Delaware State University, ¹⁰DOE Oak Ridge National Laboratory, ¹¹Ohio State University, ¹²Drexel University

NEWBio is beginning its third year of an anticipated five-year project and can identify project outcomes in several areas. Our team has identified and is addressing behavioral and institutional barriers to biomass stakeholder engagement and is modeling biological, social and economic variables that influence the availability of perennial biomass crops. Harvesting and preprocessing models are assisting stakeholders in research trials even as they undergo refinement. Project team members are analyzing key sustainability metrics, developing new crop varieties, and implementing education programs to link activities and results to diverse audiences. Our poster presentation details NEWBio accomplishments to date.
INFLUENCE OF FAN SPEED AND BILLET SIZE ON HARVESTING EFFICIENCY AND SUGAR LOSSES DURING STORAGE FOR ENERGY CANE AND SWEET SORGHUM HARVESTED WITH SUGARCANE COMBINE

Daira Aragon, Louisiana State University Agricultural Center

Sweet sorghum can be grown in Louisiana to supplement the feedstock supply for a year-round biorefinery, taking advantage of the harvesting and processing infrastructure already in place for sugarcane. Studies that include the issues of equipment efficiency, residue management and utilization, transportation costs and feedstock storage are necessary for the successful integration of these crops into the biorefinery scheme based on cane-type crops. Harvesting tests were performed in October 2014 at St. Gabriel, LA., to determine harvesting efficiency when sweet sorghum is harvested with a regular sugarcane combine harvester. Three different main extractor’s fan speed and two billet sizes were evaluated.

ENERGYCANE PRODUCTION FOR BIOMASS AND BIOENERGY FEEDSTOCKS IN LOUISIANA

Paul M. White, Jr. United States Department of Agriculture Agricultural Research Service

The poster discusses the results of the first two years of energycane production research conducted in Winnsboro, LA, and Houma, LA, as part of the USDA NIFA AFRI grant. Energycane can contribute greatly to a year around bioenergy industry in Louisiana and other areas of the SE United States. As part of this project we are leveraging existing sugar industry biomass harvesting technology as well as varieties exhibiting high amounts of fiber. Our data indicate dry matter (Brix + fiber) yields between 20 and 50 Mg/ha are achievable with existing technology. Nitrogen fertilization did not greatly affect energycane yields in the plant-cane crop. The highest biomass was harvested in November (54.1 Mg/ha).

DEVELOPMENT OF ENERGYCANE VARIETIES FOR THE SOUTHEASTERN UNITED STATES

Anna L. Hale1, Atticus Finger1, Collins Kimbeng2, Sarah Duncan2, Nisar Khan2, Arnold Parco2, and Niranjan Baisakh2

1USDA-ARS Sugarcane Research Unit, LA 70360
2LSU Ag Center, Baton Rouge, LA 70803

The USDA-ARS Sugarcane Research Unit has a long-standing breeding program aimed at introgressing genes from sugarcane’s wild relatives into commercial sugarcane varieties as a part of the Basic Breeding Program. Louisiana represents the most temperate climate where sugarcane can be grown on a commercial scale; however if the crop is to be used as a biofuel feedstock, the range of adaptation must be increased into cooler environments and more marginal lands. As a part of the AFRI-funded Sustainable Bioproducts Initiative (SUBI), a collaborative project was undertaken to develop energycane varieties adapted to Northern Louisiana and other
parts of the Southeastern United States. In 2012, 1000 genetically diverse clones were planted at the LSU AgCenter’s Northeast Research Station near Winnsboro, LA (32°08’31.92N; 91°42’23.30W), where temperatures are colder than the sugarcane growing region of the state. The clones were allowed to overwinter, and 187 were selected for stalk population, disease resistance, height, and overall vigor in 2013. Selected clones were replanted in larger plots and assessed in the spring of 2014 for disease resistance, stalk population, and the ability to re-emerge following a hard freeze. In addition, the clones were evaluated for leaf cold tolerance in the winter of 2014. A concurrent effort is underway to identify molecular markers associated with biomass production in cold environments to facilitate marker-assisted breeding of cold-tolerant energycane. Microsatellites from cold-responsive genes of an energycane Ho02-144 along with genomic SSRs were used to develop a linkage map of a first backcross population of Miscane. Thus far, 1,467 markers have been mapped and QTLs have been identified for plant height (R² = 32%), stalk diameter (R² = 14%), and regrowth (R² = 13%). Future research will focus on the development of a dense molecular map using genotyping by sequencing approaches, and comparative genomics strategy using Sorghum genome for fine resolution dissection of the QTLs to identify candidate genes and linked markers for cold tolerance traits.

**EFFECTS OF EXTRANEOUS PLANT MATERIAL ON COMPOSITION OF SWEET SORGHUM JUICE**

Shyue Lu, Louisiana State University Agricultural Center

As a potential feedstock for biofuel production, the logistics of harvesting and mechanical processing of sweet sorghum needs to be well understood. A significant factor in choosing sweet sorghum as a feedstock is that it contains fermentable sugars readily available in juice in addition to sugars available from further processing of the fiber. Extraneous material such as leaves and panicles should be utilized in order to provide maximum fiber for lignocellulosic biorefining; however, the presence of this material is observed to have an effect on the sugars extractable in juice. This study serves to quantify the differences between the juice and fiber components of sweet sorghum processed as a whole plant and sweet sorghum processed with the leaves and panicles removed.

**ASSESSMENT OF THE COMBINATORIAL EFFECTS OF SALINE AND FRUCTOSE ON BUTANOL PARTITIONING IN AQUEOUS TWO PHASE SYSTEMS**

April Lovelady, Louisiana State University Agricultural Center

The fermentation production of butanol using *Clostridium beijerinckii* optionii yields dilute aqueous solutions. This research investigated the partitioning behavior of butanol within aqueous solutions in the presence of salts, fructose, and the combination of both. The liquid-liquid equilibrium data for this aqueous system was determined via cloud point experimentation, and validated using GC-FID (gas chromatograph – flame ionization detector). The phase diagrams for the butanol are provided and discussed.
CHARACTERIZATION AND PRELIMINARY DETOXIFICATION OF ENZYME HYDROLYSATES FROM DILUTE AMMONIA PRETREATED SORGHUM AND ENERGY CANE BAGASSE

Patricia J. Pham-Bugayong and Giovanna M. Aita, Audubon Sugar Institute, Louisiana State University AgCenter,

Lignocellulosic enzyme hydrolysate detoxification is often challenging because a balance between an efficient detoxification strategy while avoiding high monomeric sugar loss has to be met. In this study, milled sorghum (*Sorghum bicolor*) and high fiber sugarcane a.k.a. energy cane (Ho 02113) bagasse were pretreated with ammonia (28% NH4OH solution), and water at a ratio of 1:0.5:8 at 160°C and 140-160 psi for 1h in a 300-mL pressure reactor. The pretreated sorghum was enzymatically hydrolyzed with different combinations of Spezyme® CP, a cellulase and Novozyme 188, a β-glucosidase and collected at various time intervals (0-72h). Enzyme loading was based on the glucan (glucose) content and mass of dry biomass (sorghum and energy cane bagasse) added (g glucan/g dry biomass). A biomass loading of 5% was used. The resulting enzymatic hydrolysate liquor (EHLx; x= number of hours) was analyzed for by- and degradation products. Organic acids, furaldehydes and phenolic acids were detected through High Performance Liquid Chromatography (HPLC) - Diode Array Detector (DAD) method, developed for simultaneous and direct detection of EHLx components. Monomeric and oligomeric sugars in the EHLx were identified and quantified through an established HPLC-Refractive Index Detector (RID) method. Detoxification strategies involving solid phase extraction (SPE), flocculant addition, ionic liquid, ion exchange resin, activated charcoal and molecular sieve adsorption and calcium salt experiments for removing by- and degradation products while retaining monomeric sugars were evaluated.

LIFE CYCLE GREENHOUSE GAS EMISSIONS, FOSSIL ENERGY USE AND EUTROPHICATION POTENTIAL FOR THE PRODUCTION OF FERMENTABLE CARBOHYDRATES

Edgardo Ortiz-Reyes, Graduate Student

Biological Systems Engineering, University of Wisconsin, Madison

Prof. Robert P. Anex, Advisor,

Biological Systems Engineering, University of Wisconsin, Madison Fermentable carbohydrates produced from energy cane, sweet sorghum, sugar beet, sugar cane, and corn were compared in terms of greenhouse gas emissions, fossil fuel use, and eutrophication potential. Energy cane, sweet sorghum, sugar beet, and corn are considered to be grown in the US while sugar cane is grown in Brazil. According to the greenhouse gas emission, fossil energy use, and aquatic eutrophication, energy cane is a low impact feedstock for the production of fermentable
carbohydrates, while sugar beet has an advantage in terms of eutrophication but it has higher greenhouse gas and fossil energy use impacts. The greenhouse gas emissions, fossil fuel use, and eutrophication potential from Sweet Sorghum are comparable to energy cane and sugar cane. Corn tends to have higher impacts than grass-like feedstocks, but the diversity of co-product reduces the impacts per unit of fermentable carbohydrate significantly.

EFFECTS OF SUGAR AND BIOENERGY POLICIES ON POTENTIAL PRODUCTION OF ADVANCED FUEL ALCOHOLS IN THE SOUTHEAST U.S.

Henry Bryant, Texas A&M University

The overall goal of this project is to evaluate the effects of current and alternative sugar and bioenergy policies on 1) US production of advanced and cellulosic, sugarcane and energy cane-based fuel alcohols, 2) US petroleum imports, 3) indirect land use change due to biofuel production, 4) national and global food insecurity 5) southeast US rural economies, 6) global trade of ag and energy commodities. The project employs i) a computable general equilibrium (CGE) model of the world economy, with substantial detail related to agriculture and bioenergy production and policy; ii) firm-level simulation models of advanced fuel alcohol production; and iii) linear activity (IMPLAN) modeling.

Thus far for this project, we have a) explored methods for incorporating TRQs into the CGE model; b) collected information about costs of production for energy cane, and biofuels produced using energy cane as a feedstock and three separate production technologies. Currently we are incorporating US production of sugarcane and energy cane-based biofuels into the CGE model. After this step is complete, we can proceed with analysis of alternative policy scenarios.

DECISION SUPPORT SYSTEMS FOR REGIONAL PLANNING AND IMPACT ASSESSMENT OF BIOREFINERIES

Satish Joshi, Michigan State University

The Energy Independence and Security Act of 2007 mandates use of 21 billion gallons of cellulosic and advanced biofuels by 2022, but scaling up the advanced biofuel sector poses major economic and logistical challenges for regional planners and biofuel entrepreneurs. This project aimed at addressing these issues, has five main components.

- Survey research aimed at assessing the acceptability of biorefineries to communities and socio-economic factors associated with the level of such acceptability.
- Socioeconomic effects of these decisions including implications for small scale and minority/tribal producers.
• A biomass harvest-shed design tool to help determine the optimal mix of woody biomass, annual crops and perennial grasses for a regional biorefinery, taking into account the necessary contract terms, feedstock costs, transport costs, GHG emissions, other environmental impacts, production capacity constraints etc.
• A logistics decision support tool to help evaluate alternative feedstock supply chain configurations.
• Contract design research aimed at helping selection of appropriate governance/institutional mechanisms to coordinate supply, these may range from markets to hierarchical arrangements such as contracts, alliances, franchising, co-operatives or vertical integration.
• A temporal dynamic agent based simulation modeling tool that can help predict the evolution of the harvest shed over time, under alternative market development scenarios.

Key findings

• In Michigan, 70% of respondents favored having a new biofuel facility in their community. Statewide, job creation dominated among the advantages listed by those in favor of the plant while long-term environmental effects and doubts about profitability were the top concerns among those opposed to the facility.
• The ranking of contract attributes by the level of importance was: price, compensation mechanism, contract length, harvesting responsibilities, shipping responsibilities, quality & quantity checking, and frequency of delivery.
• Analysis with the harvest-shed design tool using representative parameters, suggests that energy crops will likely account for a significant proportion of the optimal feedstock mix, despite higher establishment costs and the need for long-term contracts. Higher yields/acre and associated lower transport costs offset the higher costs of feedstock production. Agricultural residues are likely to be used primarily to cover shortfalls in energy crops. Spatially, energy crops will be contracted closer to the biorefinery, while agricultural residues will likely be collected from the fringe areas.
• A decentralized system will result in higher transport distance and double handling costs, which can potentially be overcome by densification and scale economies at the preprocessing depot.
• Agent based modeling of farmers’ switchgrass adoption decisions under three different market scenarios indicate that availability of alternative markets lowers farmers’ perceived risk and drives up their expected switchgrass growing gross margin, leading to higher switchgrass adoption rates.
REGIONAL BIOENERGY POLICY EFFECTIVENESS: COMPATIBILITY, INNOVATION, AND COORDINATION ACROSS THE SUPPLY CHAIN
Dennis Becker, University of Minnesota

This research evaluates the effectiveness of bioenergy policy instruments to facilitate innovation, coordination, and synchronization across regional supply chains. Our objectives are to build understanding of (1) the extent to which federal and state bioenergy policies are synchronized across the regional bioenergy supply chain (feedstock production, transport, conversion); (2) which policies and mix of policy instruments enhances bioenergy production (regulations, tax incentives, etc.); and (3) how federal and state policies interact to complement or contradict one another to foster or inhibit bioenergy development.

DEVELOPING A LIFE CYCLE ASSESSMENT MODEL FOR EVALUATING POLICY IMPLICATIONS OF BIOFUELS
Amy E. Landis/ School of Sustainable Engineering and the Built Environment, Arizona State University

The goal of this research is to quantify the policy implications of increased biofuel production, which will be evaluated through the development of an LCA-based tool to evaluate the implications of different US federal, state, and local biofuel policies. The tool can be used to evaluate different combinations of feedstocks, processing and conversion pathways to determine the effects that different policies will have on biofuel production and environmental impacts. A diverse range of agricultural, biofuels, or environmental policy options and opportunities (e.g., standards, mandates, subsidies, tax credits, trade, and agricultural assistance programs) that may impact economic, environmental, social, and other prospects will be addressed.

SOCIOECONOMIC IMPACTS OF WOOD-BASED BIOFUELS DEVELOPMENT STRATEGIES ON NORTHERN ROCKY MOUNTAIN COMMUNITIES IN THE NORTHWEST.
Dr. Darin Saul
University of Idaho

The goal for this project is to determine the optimal system or mix of systems for integrating Northern Rocky Mountain woody biomass feedstocks into a planned regional liquid biofuel production system or other efforts in the Northwest in the context of existing biomass uses and resources, and community needs. Specific objectives and activities are to
1. Utilize discreet event simulation and mathematical modeling techniques to develop effective system pathways of each technology from source to point of sale, determine boundaries where benefits and impacts move outside of the study area, and assess the number of jobs created and other benefits.
2. Model the overall viability and profitability of bioenergy strategies for woody biomass from community, state and regional perspectives.

3. Utilize county and state input/output methodologies to evaluate the economic impacts and contributions of each technology, including backward economic linkages and the appropriateness of each strategy.

4. Interview local and state elected officials, economic development professionals, industry, and other key stakeholders about knowledge and perceptions of benefits, obstacles and tradeoffs of different bioenergy development scenarios

5. Engage an advisory board in guiding the project and helping interpret project results.

The completion of this project will provide a model for understanding bioenergy development from community, county, state and regional perspectives. This information will enable the development of regional bioenergy development with maximum benefits and minimum tradeoffs from community, state, and regional perspectives.

DEVELOPING SUSTAINABLE PERENNIAL BIOENERGY CROP MANAGEMENT FOR POLLINATORS: EFFECTS OF HARVEST AND LANDSCAPE CONTEXT

PD: Dr. Claudio Gratton, University of Wisconsin; CO PD: Dr. Rufus Isaacs, Michigan State University; Dr. Doug Landis, Michigan State University; Postdoc: Dr. Brian Spiesman, University of Wisconsin; Postdoc: Dr. Ashley Bennett, Michigan State University

Conversion of marginal agricultural lands to perennial grasslands for bioenergy production has the potential to help sustainably meet US energy needs without sacrificing food production. Perennial grasslands contain greater pollinator diversity than annual bioenergy crops, such as corn, and this diversity translates to superior pollination services. However, we know very little about how the disturbance caused by harvesting will affect pollinators and the continued provision of pollination services.

We conducted an experiment to determine how the production-scale harvesting of grasslands and local floral resource diversity affects pollinator biodiversity and pollination services. In 2013 we sampled pollinators and their plant resources at 18 grassland sites in southern Wisconsin and 12 grassland sites in Michigan; half were harvested and half were left as unharvested controls.

After 1 year, we found that harvesting had no effect on pollinator species richness, composition, or visitation rate. Pollinators and pollination services depend on the abundance and richness of floral resources, components of the plant community which were not affected by the harvest. Though forb species evenness was greater at harvested sites, this did not have an effect on pollinators. A specialist stem-nesting wasp had marginally lower abundance at harvested sites.
In conclusion, short term harvesting does not have a community-level affect pollinators but harvesting may have a negative impact on some stem-nesting specialists. The effect of harvesting on forb species evenness and the dependence of pollinators on floral resources, points to the possibility that longer-term harvesting may affect pollinators indirectly through the plant community.

POLICY OPTIONS FOR DEVELOPMENT OF A REGIONAL SUPPLY CHAIN FOR BIOFUELS
Jeff Reimer, Oregon State University (Project Director is Penny Diebel, Oregon State University)

There is presently a push within the Northwest United States to develop a regional biofuel system based upon the oilseed camelina. To achieve this goal, some form of incentives will likely have to be provided to different actors within this chain, such as oilseed farmers or processors. There currently is uncertainty about the form these subsidies should take. This study develops a regional computable general equilibrium model designed to mimic key stages of the biofuel supply chain. Model counterfactuals are developed to evaluate the potential effectiveness of policies that would promote the objectives of regional policymakers. The study identifies conditions under which the industry could flourish within this region, as opposed to develop outside the region. Special emphasis is given to the difficulty of finding a policy that can successfully influence the location of economic activity.

WELFARE IMPLICATIONS OF THE RENEWABLE FUEL STANDARD WITH A REVENUE NEUTRAL CARBON TAX
Gregmar I. Galinato, Washington State University

We develop a multi-sector general equilibrium model to analyze the impact of the U.S. Renewable Fuel Standard on consumer welfare. Under the presence of preexisting distortionary taxes, we demonstrate the validity of the double-dividend hypothesis using analytic and numerical methods. We identify the classic Pigouvian Effect, Revenue Recycling Effect and the Tax Interaction Effect in solving for the optimal double dividend tax in our multi-energy sector general equilibrium model. Furthermore, we identify a fourth effect not previously identified in the literature that we call the Residual Pigouvian Effect which measures the changes in production to other sectors connected to the blended fuel sector incurring the tax. The optimal double dividend tax in the presence of market power may be lower than the Pigouvian tax level especially if the negative effects of the Tax Interaction and Residual Pigouvian Effects are significant. Simulations conducted using data from Washington, Oregon, and Idaho indicate that the imposition of a double-dividend tax is welfare improving. In all three states, our results show that the gain in consumer welfare from the double-dividend tax outweighs the loss in profit in the blended fuel sector. The double dividend tax is approximately 80% lower than the Pigouvian tax which implies that the Tax Interaction and Residual Pigouvian Effects are not
insignificant. Finally, an increase in the waiver cost or the cellulosic ethanol requirement will decrease the Pigouvian and Double Dividend taxes.

**SOCIO-ECONOMIC FACTORS AND ADOPTION OF ENERGY CROPS**

Haluk Gedikoglu, Lincoln University

Establishing a steady biomass feedstock supply is crucial for accomplishing the cellulosic biofuel production targets set by the Energy Independence and Security Act of 2007. The goal of this project is, through using the theory of new technology adoption, to analyze the socio-economic factors that impact farmers’ willingness to grow energy crops. The first objective of this project is to measure the impact of farm size, education, and off-farm employment on adoption of energy crops. The second objective is to measure the impact of producers’ attitudes, social acceptability, and being a minority limited resource farmer on adoption of energy crops and the last objective is to measure the impact of farmers’ attitudes toward risk and uncertainty, and being a member of an agricultural cooperative on adoption of energy crops. The results of the survey conducted for this project show that current level of farmers’ willingness to grow for either crop is low. Hence, there are barriers to accomplishing the goal of producing 21 billion gallons of cellulosic biofuel by 2022. It is also found that currently growing energy crops is more attractive to small farms as a source of crop diversification, rather than an alternative crop production system in the big scale by large farms.

**ECONOMIC AND ENVIRONMENTAL IMPACTS OF WOODY BIOMASS UTILIZATION IN THE CENTRAL APPALACHIAN REGION**

Jingxin Wang, West Virginia University

The goal of this proposed study is to analyze the increased utilization of wood biomass as an energy feedstock and evaluate the potential impacts on rural economic development and environmental quality throughout the central Appalachian Region. Two up-to-date online data sources will be used to determine the woody biomass availability in the Appalachian region: Forest Inventory and Analysis (FIA) and 2007 Resources Planning Act (RPA) data. A spatial model developed will be used to estimate the accessibility of woody biomass in the Appalachian region. A cradle to grave life-cycle analysis (LCA) will be performed for practical woody biomass utilization scenarios using mass and energy balances, and environmental impacts. An economic input-output (IO) analysis will determine the impact that increased biomass utilization will have on the multi-county regional economy. CGE models are built upon social accounting matrices, which are extended IO models. The results of this study will provide information that will be essential in developing the future energy policy in the central Appalachian region. In addition, the information will be used to create educational material that is geared toward
government officials and policy makers that highlights the findings about the potential economic impacts of increased woody biomass utilization in the central Appalachian region.

PREFERENCE FOR SKILLED LABOR, FACILITY LOCATION AND THE ECONOMIC IMPACTS OF A CELLULOSIC FUEL INDUSTRY IN THE SOUTHEASTERN US
Dayton M. Lambert, University of Tennessee

This research applies recent developments in the analysis of firm location determinants, applying local geographic concentration indices to determine and the extent to which employment concentration influences the location decisions of cellulosic biofuel facilities. We focus on ethanol production from switchgrass and drop-in fuels made through pyrolysis. The economic sectors analyzed would be involved in the extraction, production, and distribution of intermediate and final fuel products, and the financing of businesses supporting these activities. We augment a cost-minimizing site location model with information about local employment patterns that would be engaged with a switchgrass-based cellulosic fuel sector. Employment concentration is determined using recent developments in the derivation of the traditional location quotient as a maximum likelihood estimator. The null hypotheses are that differences arising from advantages associated with each county are not different. Rejection of this hypothesis suggests that some sites have comparative advantage with respect to location advantage. The null hypothesis also suggests that the inclusion of labor concentration information in the overall cost structure will not impact the distribution of facilities. Region-wide economic impacts that follow the addition of multiple facilities are not expected to be different after inclusion of the employment location quotients as site suitability criteria.

ASSESSING SOCIOECONOMIC IMPACTS OF FOREST BIOENERGY DEVELOPMENT ON RURAL COMMUNITIES IN THE SOUTHERN UNITED STATES
Pankaj Lal, Bernabas Wolde, Pralhad Burli, Ellene Kebede, Janaki Alavalapati, Jianban Gan

Montclair State University

The United States (US) is the largest consumer of petroleum products in the world, a significant portion of which are imported from politically unstable regions. Domestic bioenergy production can reduce the energy supply and demand gap, diversify energy sources, reduce greenhouse gas emissions, and benefit rural communities. The thirteen southern states spanning from Texas to Virginia, with around 5 million private landowners, accounting for 28 percent of total forestlands and 62 percent of the country’s total growing stock removal, are expected to play a dominant role in woody biofuel market development. We analyze the impact of woody biofuel development on rural communities in the Southern US. Specifically, we: 1) assess key stakeholders’ participation along the supply chains of loblolly pine (Pinus taeda L.) and slash pine (Pinus elliottii L.) based woody biofuel markets; 2) analyze potential direct economic and employment impacts on forestland owners and rural communities; and 3) estimate region-wide socioeconomic and distributional impacts of woody biofuel development.
Preliminary analyses of the survey data from the states of Alabama and Virginia shows that the majority of landowners already know about the use of forest biomass as energy. As expected, willingness to participate in this market is higher for higher bid price offers. At given level of bid prices, more than one third of respondents will plant loblolly pine for energy production on non-forest land. A complete data analysis will give a clearer picture of the factors that can influence landowner decisions. Our unit cost analysis indicates that, at discount rates lower than 5 percent, cellulosic ethanol can be produced competitively at prices that are 25 percent higher than the unit cost of a gasoline equivalent gallon. Sensitivity analysis indicates that unit cost is significantly influenced by changes in capital return factor and feedstock prices. If the efficiency of conversion plants is increased to 95 from 75 percent, the unit cost per gasoline equivalent gallon of ethanol can be brought down by as much as $0.28.

We will develop woody biofuel expansion scenarios based on future market emergence and socio-economic acceptability considerations. Direct, indirect, and induced impacts on stakeholders will be estimated through Input Output Analysis and Social Accounting Matrix approach. Region-wide socioeconomic and distributional impacts will be assessed using a Computable General Equilibrium model to identify winners and losers. We will discuss farm and regional impacts of woody biofuel expansion on non-metro (rural) counties in US South, including impacts on persistent poverty and minority dominated counties. This study will further our understanding of the short and long-term impacts of woody bioenergy expansion in US South and the ensuing socioeconomic impacts on rural landowners, minorities, and other rural groups. Research results will help generate public awareness, and develop education as well as outreach programs.

POLICIES TO DEVELOP PERENNIAL GRASS-BASED ADVANCED BIOFUEL SUPPLY CHAINS IN SOUTHEAST U.S.
Keith H. Coble, Dan Petrolia, Angelica Williams, Kwabena Krah
Mississippi State University

To develop a robust policy that will facilitate the performance of a biofuel supply chain, we identify producer’s preferences for grass-based biofuels contracts, in particular Giant Miscanthus, using a stated choice experiment.

We examine Southeastern U. S. farmers’ willingness to switch from current crop production to growing biofuel feedstock, particularly Giant Miscanthus. The analysis includes the effects of contract attributes such as price offered per ton, yield insurance availability, biorefinery harvest option, contract length, and establishment cost share. Farmers’ risk perceptions and risk preferences influence their everyday decisions. As a result, this study incorporates risk management behavior to ascertain how it influences their final decision on producing a risky bioenergy crop.

We employ Qualtrics, Inc. to survey a representative sample of farmers in the Southeastern U.S. (Namely: Alabama, Arkansas, North Carolina, and Mississippi). The survey comprises three
main sections. Following Dillman (2000), the first section contains set of general questions regarding their farming operations. The second part introduces the farmers to Giant Miscanthus and the choice experiment, where respondents are shown one of two versions of the choice experiment with six different scenarios. And lastly, the third part contains the risk assessment and demographic characteristics of the respondents.

A conditional logit model which considers contract characteristics and individual specific characteristics (that is, risk perceptions and risk preferences) as independent variables is specified. This study will yield estimates of the incremental values of contract length, establishment cost share, yield insurance availability and biorefinery harvest on biofuel contracts.

PLASTICS CONTAINING 85–100% LEVELS OF METHYLATED NATIVE SOFTWOOD LIGNIN
Simo Sarkanen, University of Minnesota

Annually, more than 200 million tons of co-product lignins would be generated by biorefineries in converting enough lignocellulose biologically to liquid fuels to meet 30% of current U.S. transportation needs. The time has come to determine how significant value can be added to biorefinery co-product lignins by converting them into useful polymeric materials. This project is dedicated to developing a systematic basis for formulating versatile thermoplastic blends containing 80% or higher levels of such methylated co-product lignins. Traditionally, ball-milled lignins have been considered to represent structural averages of native lignins in plant cell walls. They thus represent reasonable reference points for comparing the raw materials from different lignocellulosic sources from which lignin-based plastics are to be produced.

Between 1975 and 2000, attempts to create lignin-based materials were, almost without exception, confined to introducing lignin derivatives into other perfectly good polymeric materials. These efforts were confounded by lignin-incorporation limits of 25–40% (w/w) above which brittleness became fatal. Such findings appeared to be consistent with the premise (developed during the 1960’s) that the hydrodynamic compactness of lignin macromolecules arises from crosslinking. The consequences of the powerful noncovalent interactions now known to prevail between aromatic lignin substructures could not have been anticipated at that time (more than 40 years ago).

Our group had, however, overcome these lignin-incorporation limits in some homogeneous polymer blends that contained 85% (w/w) softwood kraft lignin or 80% levels of its methylated derivative. We have now established that plastics with 85–100% (w/w) methylated native softwood lignin contents can reach 50–70 MPa in tensile strength with elongations at break between 7 and 14%. The mechanical properties of these new materials are not influenced by entangled polymer chains but rather governed by interactions between lignin complexes through their peripheral chain segments. Such a model is consistent with findings from atomic force microscopy and X-ray powder diffraction studies.
The new methylated lignin-based plastics are considerably better than polystyrene in tensile behavior, and their mechanical properties can be improved significantly with small proportions of (homogeneous) blend components. Thus, the flame-retardant, tetrabromobisphenol–A, at 10% (w/w) incorporation levels forms a blend with 66 MPa tensile strength at a 9% elongation at break. More remarkably, blending with only 5% (w/w) 400-molecular-weight poly(ethylene glycol) leads to a tensile strength of 65 MPa for the material with an elongation at break of 10%. There are other examples of comparable interest.

An entirely novel approach has been devised for identifying efficacious plasticizer-interaction targets in lignin macromolecules. It involves an analysis of the product distributions resulting from monolignol dehydrodimerization in the presence of the various lignin substructures respectively represented as the corresponding methylated dilignols. To this end, syntheses of nonphenolic lignin β–O–4, β–5, 5–5 and 4–O–5 model dimers have been carried out, as have those of [β–13C] and [5–13C] coniferyl alcohol. Products from monolignol dehydrodimerization reactions have been characterized by LC–MS. An HPLC-based method is being developed to quantify the dimers formed in these reactions and evaluate the impact of dilignol template models on the product distributions.

FROM INDUSTRIAL WASTES TO A FUEL BRIQUETTE

Curtis Frantz¹,², Matt Lumadue², Allura Jiles², Brett Diehl¹, Cesar Nieto Delgado², Young Dong Noh³, Jim Furness⁴, Dave Paulsen⁴, Fred Cannon², Sridhar Komarneni³, and Nicole Brown¹

The Pennsylvania State University, ¹Department of Agricultural and Biological Engineering, ²Department of Civil and Environmental Engineering, and the ³Department of Ecosystem Science and Management; ⁴Furness Newburg Inc.

Our team has developed a fuel briquette from several industrial waste materials, including lignin, silica ash, anthracite fines, and a by-product binder (patent pending). This presentation will review the availability of the constituent waste materials, an overview of the technoeconomic analysis we’ve conducted to date, the preparation of the briquettes, the evaluation of the bricks as a fuel during several industrial scale demonstrations, and will briefly describe elements of the fundamental evolution of the chemistry and strength of the bricks following different thermal exposures. Based on our mechanical testing results (via compression tests), we conclude that lignin adds mechanical strength to briquetted anthracite fines, allowing the briquettes to be effective in high temperature cupola environments. Solid state NMR results showed the likely mechanism for this strength is the increasing aromatization of lignin during high temperature pyrolysis. Hence, lignin serves as a binding material in the thermal regime of 500°C to 1100°C, which corresponds to the “heat zone” of a foundry cupola. Unconfined compression strength tests revealed different performance from various lignin sources, and from different sources of silica.
DEVELOPMENT OF TOOLS AND STRATEGIES TO INCREASE SUCCINATE PRODUCTION BY ACTINOBACILLUS SUCCINGENES ON GLYCEROL
Claire Vieille, Michigan State University

Developing a microbial process that converts glycerol into succinate in high yields would increase the economic sustainability of biodiesel production. *Actinobacillus succinogenes* is one of the best natural succinate producers, and it grows on glycerol by aerobic and anaerobic respirations. We have previously identified microaerobic conditions in which glycerol-grown *A. succinogenes* produces succinate in high yield. We have also developed a markerless knockout method for *A. succinogenes*.

Here we describe the strategies we are exploring to engineer *A. succinogenes* for increased succinate production. In the first approach we are constructing a library of artificial promoters whose individual strength will be measured using *lacZ* as the reporter gene in an *A. succinogenes ΔlacZ* strain. Promoters of different strengths will then be tested to express the 1,3-propanediol production pathway in *A. succinogenes* to allow for fermentative growth with minimized 1,3-propanediol production and maximized succinate production. In our second approach, we are exploring the option of inhibiting the expression of the acetate production pathway with a synthetic small RNA. While we are establishing proof of concept using a synthetic antisense RNA against *lacZ* as reporter gene, we will characterize the types of small RNAs present in *A. succinogenes* by RNAseq. The RNAseq results will inform our strategy to construct a small inhibitory RNA targeting acetate production genes.

BIODIESEL CO-PRODUCTS FROM BRASSICACEAE OILSEEDS
Matthew J. Morra, University of Idaho

Brassicaceae oilseed crops including rapeseed (*Brassica napus*), mustard (*Brassica juncea* and *Sinapis alba*), and camelina (*Camelina sativa*) exhibit rotational and environmental quality benefits making them excellent choices as rotational crops for the production of advanced liquid biofuel feedstocks, however unacceptable grower returns limit feedstock production. Our goal is to ensure economic viability of liquid biofuels production from rapeseed, mustard, and camelina by developing co-products from the 1) seed meals remaining after oil expression and 2) glycerol generated during biodiesel production. Glucosinolates have been extracted from Brassicaceae seed meals and extracts utilized as biopesticides. Optimum conditions for glucosinolate extraction have been determined and formulated products tested on target organisms to develop efficacious products. Glycerol generated during biodiesel production is being used as a feedstock for alcohol production. We have converted glycerol hydrothermally to ethanol and additional products. We are developing catalysts for the hydrogenation, dehydration, and/or cracking of glycerol, and characterizing the effects of major parameters to optimize the process for primary alcohol production. Successful completion of this project will promote the development of entirely new industries related to biofuels and bioproducts, thereby helping to revitalize agricultural communities.
NANOFIBRILLATED CELLULOSE AND A BIOFUEL CO-PRODUCT
Ronald Sabo, USDA Forest Service, Forest Products Laboratory
presented by J.Y. Zhu

This research is aimed at integrating the production of biofuel with nanocellulose as a forest biorefinery co-product. The morphology and properties of cellulose nanofibers created after significant sugars have been liberated by aggressive enzymatic hydrolysis using commercial enzymes have been examined. The effects of processing conditions on the physical and mechanical properties of films and composites made from these various cellulose nanofibers are being investigated, and a range of properties have been observed. Methods for improved properties and scalable processing are being explored. Production and purification of first pick endoglucanases, exoglucanases, and a beta-glucosidase are in place. These are thermostable enzymes which will allow treatment of cellulose at elevated temperatures not possible with the commercial source enzymes used in our previous studies. Sugar release from cellulose with these thermostable cellulases is being characterized. Screening for recombinant auxiliary proteins that may be useful in nanocellulose treatments has begun. Chimeric GFP fusions are made with protease sites for purification of “tagless” native proteins. This strategy allows detection of previously uncharacterized proteins (e.g. from genome studies) with removal of extraneous N-terminal or C-terminal tags that can aid in purification but interfere with the function of the native protein if left in place. These tailored enzymes have been used to produce cellulose nanofibers and were compared to commercial enzyme formulations. Research continues on enzymatic conversion of glucose to potential platform chemicals as biorefinery co-products.

Methods for producing reinforced composites using various cellulose nanofibers, including those produced by enzymatic hydrolysis as well as model nanofibers, were examined. Gel spinning of continuous fibers was performed, and the effects and limitations of material and process variables and drawing methods were being examined. Drawn films of different formulations were produced to evaluate formulation effects (e.g., cellulose content, crosslinking agent), heat treatment, and drawing approaches, and the most successful approaches resulted from using cellulose nanofibers as reinforcement in polyvinyl alcohol. In gel spun fibers of polyvinyl alcohol, we found that adding small amounts of short cellulose nanofibrils facilitated matrix orientation during drawing. This led to improvements in strength properties beyond those expected by reinforcement alone. Furthermore, the use of cellulose nanofibers to improve mechanical properties of thermoplastics and to facilitate the nucleation of polymers and the cellular structure of foamed composites has been examined. Cellulose nanofibers blended with various polymers, often using novel techniques, typically resulted in increased strength and modulus, as well as favorable reduction in the size of cellular structures in foamed composites. In one example, using a small-batch, water-assisted compounding approach, we were able to
blend cellulose nanocrystals with Nylon 6. This represents a way to incorporate nanocellulose into an engineering polymer, which typically have high melting temperatures (e.g., Nylon 6 melts at about 225°C), without significantly degrading the nanocellulose. We continue to explore and evaluate methods for incorporating cellulose nanofibers into composites.

**THERMOSETTING ADHESIVES AS COPRODUCTS OF FERMENTABLE SUGAR FROM WOODY BIOMASS**

William T. Y. Tze, University of Minnesota

Enzymatic saccharification of woody biomass often leaves behind solid residues that are rich in lignin. In this study, we attempted to tap the adhesive nature of lignin by converting such residues into a heat-cured adhesive. Our research objectives for this poster are to examine effects of 1) grinding (increased surface area) and 2) addition of a cross-linking (curing) agent on the bonding of saccharification residues to wood substrates. First, aspen wood flour was enzymatically hydrolyzed to attain 80% glucose removal. The wet solid residues were ground using a disk mill and then applied onto wood strips in the presence of a curing agent at different dosages. Results show that the bond strength of adhesives made of saccharified residues was 50% higher if they were pre-ground as opposed to un-ground. Moreover, the bond strength was 250% higher if the pre-ground adhesive was from saccharified residues as opposed to unsaccharified biomass. With addition of a cross-linking agent, the wood bond strength can be enhanced to attain that of phenol formaldehyde, a commonly used fossil-based adhesive for wood bonding. Overall, by transforming, with minimum conversion, saccharification wastes into adhesive products, this study has the impact of increasing economic viability of the bioenergy system.

**FUEL AND OXYGENATE CO-PRODUCTS FROM BIOMASS FRACTIONATION AND ADVANCED CATALYTIC CONVERSION PROCESSES**

Mario R. Eden¹, Christopher B. Roberts¹, Steven E. Taylor², Sushil Adhikari²

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Forests in the U.S. contain significant levels of underutilized woody biomass in the form of forest harvesting residues, small diameter unmerchantable trees, and biomass available due to forest health. In Alabama alone, over 14.6 million tons of this material is available for production of liquid fuels and chemicals on an annual basis. These levels of biomass feedstock production can contribute significantly to the nation’s goals for energy security and economic viability if technological advances are achieved in the thermochemical conversion platforms.

The overall goal of this research program is to design viable hydrocarbon production strategies by integration of biomass fractionation technologies followed by technically well-informed
application of thermochemical conversion approaches. Synergistic collaboration between experts in chemical engineering and biosystems engineering allows for a systems level approach to the optimization of the biomass to hydrocarbon chemical/fuel lifecycle including design/characterization of the enabling catalysts. The Auburn University team employs a holistic methodology utilizing a systematic and flexible process integration/optimization based framework to identify product distributions and processing routes for integrated biorefineries. This project leverages ongoing research by taking advantage of a unique set of testbeds at AU consisting of biomass fractionation and conversion technologies, specifically for supercritical phase Fischer-Tropsch synthesis and high value chemical co-production.

Biomass fractionation technology coupled with a pilot-scale gasification unit enables systematic analysis of the downstream conversion viability and potential for value addition for each feedstock constituent, i.e. cellulose, hemicelluloses and lignin. As a specific example, we have studied an innovative supercritical phase Fischer-Tropsch Synthesis (SCF-FTS) process developed at AU using biomass derived syngas with particular attention on the impact of novel nanoscale catalysts on reaction performance. This dense supercritical media enables significant enhancement of middle distillate products while drastically reducing undesired methane formation, thus improving the overall carbon utilization. Additionally, we have demonstrated that the use of properly selected Fe-based catalysts in supercritical fluid reaction media results in a product stream consisting of more than 30% aldehyde species plus significant concentrations of 1-olefins. This affords higher value than conventional FTS approaches.

AN AGENT-BASED MODELING SYSTEM FOR BIRD MIGRATION
Eli S. Bridge, University of Oklahoma

Agent-based models typically involve populating a real-world landscape with agents that represent an animal species or community of interest. With a simulated population of agents that respond to the landscape in a realistic way, we can use agent-based models to explain and predict population trends and trajectories. We generated an agent-based model to investigate migration patterns in a small songbird, the Painted Bunting. Our virtual birds were programmed to move in accordance with a simple animal movement model that mimics the capabilities of Painted Buntings. We then used millions of agents to search for migration paths across the US and Mexico that maximize exposure to primary productivity. We then compared the highest ranking virtual tracks to migration routes of real birds equipped with tracking devices and found that the simulations were similar to what Painted Buntings actually do both in terms of the path and EVI exposure. There were, however, notable differences in the timing of migration, which are likely due to life-history constraints (e.g. feather molt) that were not built into the model. We hope to use this modeling approach to investigate how changes to the landscape associated with biofuel conversion will affect the behavior and survival of migratory birds.
**SORGHUM-COLLETOTRICHUM INTERACTIONS: IDENTIFICATION OF NOVEL SOURCES OF RESISTANCE**

Surinder Chopra, Pennsylvania State University

Our goal is to understand *Sorghum-Colletotrichum* interactions so that during introduction of sorghum as a new feedstock crop, disease mitigation strategies can be developed. Our work has been focused on 3-deoxyanthocyanidin (3-DA) phytoalexins that are required for resistance against *C. sublineolium* in sorghum. By the use of an active transposable element, *Candystripe1*, isolation of sorghum mutants in the 3-DA pathway was done previously. We have now screened new sorghum near-isogenic lines as well as Association Mapping populations and unique germplasm accessions from ICRISAT, and identified new sources of resistance. In addition, we are now identifying and purifying elicitors and fungal effector(s) that may be important for triggering the early signaling events. Characterization of different strains of fungal pathogens and the associated pathogenicity factor will be discussed. Moreover, transgenic maize plants have been developed and being characterized to test sorghum genes that play a critical role in anthracnose resistance.

**SWITCHGRASS-APHID INTERACTIONS – HOW FAR ALONG ARE WE?**

Gautam Sarath, United States Department of Agriculture, Agricultural Research Service

This grant focuses on the study of switchgrass-insect (hemipteran) interactions. In this poster we will discuss work that has been published so far, work that is nearing publication, and work that remains to be done. Our studies have utilized a range of tools including EPG to assess modes of resistance in diverse switchgrasses. These studies have indicated that different resistance mechanisms are present in switchgrass. It should be possible to exploit these “resistance-mechanisms” to breed for plants with improved resistance to piercing-sucking insects.

**GRASSLANDS IN COLORADO AGROECOSYSTEMS SUPPORT DIVERSE NATIVE BEE ASSEMBLAGES**

Mary Jamieson, University of Wisconsin - Madison

Increasing demand for and supply of cropland-derived biofuels is expected to alter land-use and land-cover in the agricultural landscape. Such effects may also impact wildlife inhabiting agroecosystems. Our research aims to provide information needed for identifying potential risk factors for bees and for developing strategies for pollinator conservation in the Colorado high plains region. We used the Department of Energy’s Billion-Ton Update (BT2) projection models to identify six Colorado counties with significant biomass supply potential for future bioenergy feedstock. In Colorado, projected supplies of bioenergy feedstocks include corn and wheat residues and perennial grasses, especially from agricultural production areas in the high plains region. We selected 32 field sites (focal grassland habitats) across these six counties that
represented a range of variation in the habitat matrix (surrounding landscape dominated by corn, wheat, and/or perennial grasses). We surveyed bees and floral resources at field sites, monthly from May-September in 2013 and 2014. For bee surveys, we used a combination of passive and active sampling methods, including bee bowls, vane traps, trap nests, and hand-netting, for a 24-hr period, once per month. We plan to use field survey data and spatial analyses of landscape attributes to address the following objectives: 1) to determine how local and landscape factors influence bee abundance and diversity, 2) to explore bee floral and nest resource use in the agricultural landscape, and 3) to assess potential risks posed by land-use and land-cover changes associated with shifts in agricultural practices and production systems. Preliminary results show that grassland habitats within an agricultural matrix can support abundant and diverse native bee communities. Additionally, native bees in the Colorado high plains appear to be resilient to current agricultural land-use. Finally, our study indicates that Conservation Reserve Program (CRP) plantings are especially important for supporting bee diversity in this region.

THE IMPACTS OF LIGNIN MODIFICATIONS ON FUNGAL PATHOGEN AND INSECT INTERACTIONS IN SORGHUM
Scott Sattler, University of Nebraska-Lincoln

Modifying lignin content and composition are major targets for bioenergy feedstock improvement. Lignin has also long been implicated as playing a critical role in plant defenses against fungal pathogens and insect herbivory. It is important to determine how modifying the lignin biosynthetic pathway of sorghum (*Sorghum bicolor*) will affect its interactions with three major insect pests: fall armyworm (*Spodoptera frugiperda*), corn earworms (*Helicoverpa zea*) and greenbugs (*Schizaphis graminum*), and three major fungal pathogens, which cause anthracnose (*Colletotrichum sublineolum*), stalk rot (*Fusarium thapsinum*) and charcoal rot (*Macrophomina phaseolina*). *brown midrib* sorghum mutants are impaired in lignin biosynthesis, and transgenic sorghum lines were develop to overexpress genes in this pathway. None of the sorghum lines have shown increased susceptibility to the insects or the pathogens tested. In contrast, some lines have shown greater resistance to specific insect pests or fungal pathogens. The causes of the increased resistance are being examined through gene expression and metabolite profiling experiments. Phenolic compounds derived from this pathway are currently being investigated for their ability to inhibit fungal and insect growth. In contrast, altering lignin synthesis in bioenergy sorghum may confer increased resistance to insect pests and fungal pathogens.
IN SILICO IDENTIFICATION AND CHARACTERIZATION OF NB-LRR ENCODING RESISTANCE GENES IN THE BIOENERGY PLANT SWITCHGRASS (*PANICUM VIRGATUM* L.)

Bingyu Zhao, Virginia Polytechnic Institute and State University

Switchgrass has received attention for its potential use as a second generation biofuel feedstock. Sustainable switchgrass biomass production could be negatively impacted by the epidemics of various disease problems, such as switchgrass rust. Therefore, the molecular mechanisms underlying tolerance to various diseases must be elucidated. The majority of plant disease resistance (R) genes belong to a large family of nucleotide binding - leucine rich repeat (NB-LRR) genes that can be classified into two major groups: Toll-IL-1 receptor (TIR)-NB-LRR and coiled-coil (CC)-NB-LRR genes. In this study, we used a homology-based computational method to identify 610 putative NB-containing R genes in the newly released draft genome of switchgrass. As expected, no TIR-NB genes were discovered in the switchgrass genome. Interestingly, 28 genes were identified that contain unique domains other than CC and LRR domains. RNA-sequencing of Dacotah, a rust-susceptible switchgrass cultivar, and Alamo, a rust-resistant switchgrass cultivar, verified the expression of several of these resistance gene candidates. Currently, single nucleotide polymorphisms (SNPs) are being identified in the NB-containing genes that are expressed in both Alamo and Dacotah in order to develop molecular markers for breeding of disease resistance. The results of this study will aid in understanding the genetic mechanisms that control disease resistance in switchgrass and may lead to the development of switchgrass cultivars with improved disease tolerance.

INTEGRATING FLOWCAM AND FLUORESCENCE IN SITU HYBRIDIZATION (FISH) FOR RAPID DETECTION OF *BRACHIONUS CALYCIFLORUS* IN ALGAL CULTURE:

Xuezhi Zhang and Milton Sommerfeld

Arizona State University

*Brachionus calyciflorus*, a fresh water rotifer species, has been identified as one of the major predators in algal cultures for biofuel production through our previous national-wide survey. Rapid detection of this organism is hampered by its relative low abundance in algal mass culture, as well as its complicated life cycle. Traditional microscopic identification and quantification takes hours for sample preparation, and can be hardly used for identification of the resting eggs of this organism. An efficient detection tool is needed for control and mitigation of rotifers contamination in algal culture. A FlowCam-based technique was developed in this study. This bio-imaging approach has been proven to be 100-fold more sensitive than typical microscopy for detection and quantitation of rotifers in algal cultures. To further improve the sensitivity, a species-specific DNA probe targeting mitochondrial cytochrome c oxidase subunit I (COI) of *B. calyciflorus* was designed and utilized for fluorescence in situ hybridization (FISH) analysis. The
optimized FISH protocol can detect both free-swimming rotifers and resting eggs, which will be useful for better understanding the occurrence, distribution and population dynamics of rotifer predators in algal culture systems.

IDENTIFICATION OF GENES CONTROLLING DISEASE RESISTANCE TO MITIGATE DISEASE PRESSURE OF BIOENERGY CROPS
Guotian Li, University of California- Davis

We used the probabilistic functional gene network for rice, RiceNet (http://www.functionalnet.org/ricenet/), to identify potential candidates for engineering disease resistance in rice and switchgrass. The expression profiles of these genes were analyzed in response to *Xanthomonas oryzae* (Xoo), *Maganporthe grisea* and *Bipolaris oryzae* infection using publicly available rice microarray data. The shortlisted genes were transformed into rice and tested for resistance to the bacterial pathogen, *Xanthomonas oryzae pv oryzae*. Based on these studies, we selected two genes, *WAK25* (Wall-associated kinase) and *SnRK1A* (SNF1-related kinase), for detailed investigation in rice. Overexpression and silencing of these genes were generated in both Kitaake and Kitaake-XA21 backgrounds and tested for resistance to two biotrophic pathogens (*Xanthomonas oryzae pv oryzae* and *Magnaporthe oryzae*) as well as two necrotrophic pathogens (*Rhizoctonia solani* and *Bipolaris oryzae*). Our results suggest that *WAK25* is a positive regulator of resistance to biotrophic pathogens but negative regulates resistance to necrotrophic pathogens in rice. In contrast, *SnRK1A*, appears to be a positive regulator of resistance to all the four pathogens. We have successfully established switchgrass transformation in our lab and generated 13 independent lines overexpressing *WAK25* in switchgrass that were inoculated. These lines do not show enhanced resistance compared with the control A4 switchgrass line, which already shows moderate resistance to rust. We have also shown that overexpression of *Arabidopsis NPR1*, a key regulator of systemic acquired resistance and NH1 (the rice ortholog of NPR1) in rice confers robust resistance to bacterial and fungal pathogens. We have further shown that another NPR1 paralog in rice, called NH3, driven by its own promoter, also confers enhanced disease resistance to *Xoo*. These genes are being used to engineer Switchgrass for enhanced resistance.

A WATER AND RISK MANAGEMENT TOOL FOR SUSTAINABLE PRODUCTION OF BIOENERGY FEEDSTOCKS
John Jifon, Texas A&M University System

The cultivation of crops primarily for energy is expected to provide numerous benefits to society such as lessening dependence on imported oil, mitigating climate change, and creating jobs. Rapid expansion of the biofuels industry in recent decades will most likely lead to intense competition for land and water resources especially in regions where water is already scarce. The amount of water required to grow and convert feedstocks into biofuels varies tremendously depending on location, feedstock cultivar, farming practices (especially irrigation management), and end-product. Current estimates of water use (gallons of water used per gallon of biofuel
produced) based on corn and switchgrass feedstocks severely underestimate the feasibility of sustainable biofuel production in regions where these crops are currently not produced. This project will use the combination of farm-level investigations, computer simulations and economic analysis to address the growing issue of bioenergy impacts on water quantity and quality. Estimates of water requirements to grow and convert feedstocks into biofuels are being evaluated under different water availability scenarios that are representative of the southeast U.S. This information will then be used to develop tools (models) that can assist growers, biofuel producers, investors, and policy makers to determine which feedstocks are suitable for production in specific regions, and which feedstock combinations can result in profitable biofuel production while minimizing negative impacts on critical resources such as water. During this first year of investigations, seed cane scale-up plantings were established in four locations with contrasting growing-season durations and water resources. Preliminary observations indicate that some of the newly-developed energy cane genotypes can tolerate irrigation with poor-quality water (>5dS·m⁻¹) in semi-arid locations.

CARBON SEQUESTRATION AND GREENHOUSE GAS EMISSIONS ASSOCIATED WITH CELLULOSIC BIOENERGY FEEDSTOCK PRODUCTION ON MARGINAL LANDS IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY
Michael Blazier, Louisiana State University Agricultural Center

Switchgrass and cottonwood are sequestering 90-220% more C than a conventional soybean-sorghum rotation at the sites observed in this study. Carbon was sequestered predominately in above- and below-ground biomass, and for cottonwood a substantial amount of C was also sequestered in surface organic matter. The accumulation of C in mineral soil has been greater for switchgrass and cottonwood than soybean-sorghum. Switchgrass has been a greater source of labile C in soil than cottonwood and soybean-sorghum at all sites, which is likely due to its dense, fibrous root system. However, soil microbial biomass C at all sites was lower for switchgrass than cottonwood and soybean-sorghum at all sites. This finding may be due to the nearly complete annual harvesting of all above-ground biomass for switchgrass. Emissions of CO₂ have been lower for cottonwood than the other types of vegetation at two of three sites, which was likely due to the lower total biomass associated with the cottonwood plantations. Methane flux rates have been low for all treatments at all sites. Cottonwood has exhibited lower N₂O emissions, which is likely due to the absence of N fertilization for cottonwood. Results of this study have been developed into journal articles, conference proceedings, and a magazine article and shared with diverse clientele through press releases. Future plans include the development of C life cycle analyses for these cropping systems.

TOTAL WATER USE AND SOURCE PARTITIONING IN WOODY BIOENERGY CROPS
Doug P. Aubrey, Georgia Southern University

The southern United States is a potential leader in producing biofuels from intensively managed short rotation (8-12 years) cellulosic crops such as southern pines, and native and non-native
hardwoods. Pine and eucalypt are benchmark crops for achieving economic production levels, but their accelerated development under intensive management has raised concerns that fast-growing bioenergy crops could reduce water resources, especially stream flows and groundwater, relative to other land cover types or less intensively managed woody crops. Moreover, differences in the characteristics of water acquisition and use between these two species, such as rooting structure and stomatal conductance, coupled with the high potential evapotranspiration (ET) and relatively shallow groundwater tables of the southeast, may have critical implications for sustainable bioenergy production. Currently, we know relatively little about total water consumption and potential hydrologic impacts of these two major crop species when grown under intensive management to meet energy demands.

The overall goal of this proposed research is to compare the water relations and the impact on local hydrology of intensively managed pine and eucalypt woody bioenergy crops over stand development. We have established paired plantings of loblolly pine and eucalypts at the shallow and deep ends of a groundwater depth gradient. We will quantify and compare the biomass production potential and absolute water use of these two preeminent woody bioenergy crops over stand development. We will construct annual hydrologic budgets by quantifying the hydrologic inputs (precipitation and interception) and outputs (evaporation and transpiration) of the experimental plots and characterize how the sources of transpiration water (current precipitation, stored soil pore water, or groundwater) differ between the species through early stand development and as a function of groundwater depth, leaf area, rooting depth, and seasonality by applying a mixing model to δ²H and δ¹⁸O isotope data collected from xylem water. Empirical data derived from this study will be used to parameterize a process-based model to estimate watershed-scale changes in the hydrologic cycle that may result from shifting land cover from current native vegetation types to woody bioenergy crop system scenarios.

**IMPACTS OF FOREST BIOMASS REMOVAL ON SOIL QUALITY AND BIODIVERSITY**

Mark Coleman, Steve Cook, Martin Jurgensen, Daniel Lindner, Deborah Page-Dumroese

University of Idaho

We summarize project objectives, briefly describe ongoing efforts and highlight the latest research findings for invertebrate diversity research.
Carbon and nitrogen fluxes are important components of sustainability of a biofuel production system. Production of forage sorghum (Sorghum bicolor) for lignocellulosic biomass is under consideration in the high-heat, high-irradiance, and thus high productivity, environment of the Imperial Valley, low desert of CA. This seasonally very hot environment may reflect future production scenarios following ongoing climate change. Our objective in this system is to engage a data-model fusion paradigm to characterize the controls on soil surface NOx, N2O, and CO2 fluxes and net ecosystem exchange (NEE) of CO2. Initial results measuring NEE, total evaporation, and and soil CO2 emissions have shown the high magnitude of fluxes and supports new modeling approaches linking photosynthesis and respiration (Oikawa et al. 2014; Oikawa et al. In Press). Measurements of NOx suggest potential fluxes up to 65X those predicted from conventional modeling schemes. Our ongoing work is revising existing models and scaling to regional air quality effects. Measurements of N2O emissions are suggesting similarly large unexpected fluxes compared to conventional models and highlight the interactions between N and C availability on N2O emissions. Continuous measurements of N2O fluxes show diel variation related to both temperature and photosynthesis derived C inputs. To better understand the regulation of trace gas emissions we began a series of isotopic measurements of C and H2O using in-situ field sensors. These measurements are helping to further partition net fluxes into distinct processes and evaluate translocation rates between plants and soils. This work is looking towards a field measurement intensive life cycle assessment of multiple sustainability metrics to better understand potential benefits and consequences of biofuel production in our high temperature environment system

HIGH PLANTING DENSITIES FOR SOUTHERN PINE BIOENERGY FEEDSTOCK PRODUCTION: FILLING IN THE CARBON LIFE CYCLE ANALYSIS.
Daniel Markewitz, University of Georgia

Loblolly pine (Pinus taeda L.) is the most commercially important southern pine species making up over 50% of the standing pine volume (1.4 billion cubic meters) and occupying 11.7 million hectares. The importance of loblolly pine as a bioenergy feedstock has continued to grow in the Southeast. This research fills a gap in the region by investigating modifications and optimizations of pine plantations for biofuel feedstock production or for integrated product objectives including traditional resources of timber and fiber along with biofuel feedstock production. Project PIs have been investigating high planting densities (up to 4448 trees/ha (1800 trees/ac) as opposed to the common 1483 trees/ha (600 trees/ac) as a means to augment the product outputs from pine plantations such as thinnings for biofuel feedstocks at relatively young
ages. Three critical components of the carbon life cycle of these silvicultural systems addressed by the research include 1) aboveground carbon accumulation, 2) belowground carbon accumulation and storage, and 3) N₂O efflux. This poster highlights findings from this research that include an improved system of equations for estimating all components of loblolly pine trees aboveground (i.e., stemwood, stembark, live branch, dead branch, and foliage), improved estimates of belowground biomass and impacts of soil type in the Piedmont and lower Coastal Plain growing regions, and potential release rates of N₂O from common N fertilizers (i.e., urea, NH₄NO₃, or diammonium phosphate (DAP)).

EXAMINING THE IMPACTS OF PYROGENIC CARBON ON ORGANIC MATTER STORAGE IN FOREST SOILS
Sanjai J. Parikh, University of California, Davis

In sandy forest soils, organic carbon stores are easily lost to leaching. Forest thinning materials represent a valuable source of bioenergy, and the biochar produced from the same pyrolytic process could be incorporated into course textured soils to combat the loss of organic carbon. The aim of this study is to determine if the unique chemical and physical properties of biochar can increase the retention of carbon in sandy forest soils. A thermosequence of wood biochar was produced from Ponderosa pine trees, which were chipped, dried, and pyrolyzed at 300, 500, 700, and 900 °C. The physical and chemical properties of the chars were analyzed. Soil column leaching experiments were conducted to quantify changes in the retention of DOC and nitrate in the leachate of forest soils with 2% biochar additions. The sorption of carbon measured in the sand columns with char additions also show that the 900 °C pine char was the only biochar of the four tested in this study that increased retention of C, compared to the control. The difference in the sorption capacity of the four chars was also confirmed by sorption isotherms, showing increased sorption with increasing pyrolysis temperature (e.g., from a 160 mg C L⁻¹ solution: 50.8 and 119.5 mg C g-char⁻¹ for the 300 and 900 °C pine char, respectively). In addition, column experiments of 900 °C pine char with sand columns showed that the char was able to reduce solution nitrate (NO₃⁻) concentrations by 10 mg NO₃⁻/L, compared to the sand control which did not retain any NO₃⁻. These data suggest that soil amendments of pyrogenic carbon can effectively reduce DOC leaching and enhance soil carbon stocks.
DIRECT EFFECTS OF CONVERTING CONVENTIONAL CROPPING SYSTEMS TO BIOFUEL CROPPING SYSTEMS ON ECOSYSTEM SERVICES FOR THE SOUTHEASTERN U.S.A.

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Conventional food, feed, and fiber agricultural landscapes are already being converted to biofuel cropping systems, and this is expected to intensify as demand for bioenergy grows. However, the implications of this conversion for agroecosystem services are not well understood. The objectives of this project are to quantify and compare the effects on aboveground primary production, water use and water quality, and soil carbon of converting current conventional cropping systems in the Southeast to emerging biofuel cropping systems, with and without land application of bio-char and evaporated vinasse generated from the conversion of the crop to biofuel. Two large field experiments, one at Jay, FL, comparing an annual sweet sorghum biofuel cropping system to a cotton-peanut rotation, and the other at Citra, FL, comparing a perennial elephantgrass biofuel cropping system to a perennial bahiagrass pasture system were established in 2012/2013. During the first growing season (2013) following establishment, dry biomass yield was greater for elephantgrass compared to bahiagrass, but the elephantgrass yields were similar across all treatments. Similarly, sweet sorghum aboveground dry matter production was greater than conventional peanut and cotton cropping systems, but sorghum dry matter yields were similar across sorghum treatments. Preliminary data on soil C indicated enhancement of soil C in the upper soil profile by bahiagrass and to a lesser extent by biochar-amended elephantgrass. In contrast, high fertilizer input and vinasse-amended elephantgrass plots tended to exhibit reduced soil C in the upper soil profile. Preliminary results from the first growing season also indicated higher soil moisture, greater drainage, and reduced evapotranspiration from bahiagrass compared to elephantgrass. At Jay, differences in water cycling between sorghum and conventional crops were less pronounced, but there was a tendency for high input sorghum to be associated with lower soil moisture and reduced drainage. Additionally, biochar-amended sorghum tended to have higher soil moisture and increased drainage. Preliminary results have indicated some potentially interesting effects of bioenergy cropping systems on ecosystem services compared to conventional cropping systems and we look forward to continued data collection and analysis.
EVALUATING HOW MARKET AND POLICY AFFECT CELLULOSIC BIOFUEL FEEDSTOCK PRODUCTION IN MARGINAL LAND OF UPPER MIDWEST AND ITS CONSEQUENCES ON WATER SUSTAINABILITY IN A CHANGING CLIMATE

Haochi Zheng (PD); Zhulu Lin (co-PD, presenter)
University of North Dakota

The overall goal of this proposed project is to assess the impact on water sustainability of cultivating cellulosic bioenergy crops driven by the crop market/bioenergy policy. The potential impact will be analyzed and contrasted in two major river basins in the Upper Midwest – the Red River of the North basin (bordering MN, ND, and SD) and the Republican River basin (bordering KS, NE and CO), each has distinctive hydrological characteristics and irrigation scheme. The analysis will focus on growing cellulosic bioenergy crop, switchgrass and collecting crop residuals from wheat and sorghum, under various management practices (crop rotation, fertilization inputs, tillage, residual collection, and irrigation) on marginal land to identify the most sustainable biomass production for the region’s water resource. During the 1st project year, the team has accomplished the following tasks: 1) developed a baseline economic land-use model; 2) finished the basic SWAT model set-up; 3) spatially identified the marginal land for the Red River of the North basin based on soil land capacity class; and 4) deployed the buoy in Devils Lake, ND and started monitoring water quality in real time.

WATER YIELD AND QUALITY THROUGH AN INTEGRATED WOODY AND HERBACEOUS BIOFUEL FEEDSTOCK PRODUCTION SYSTEM
Rodney Will, Oklahoma State University

We are currently in the first year of a five-year project. We will present the rationale and summary of our project as well as our current activities.

Rationale for the Project: Woody plant encroachment into grasslands is a worldwide issue that fundamentally changes water and carbon cycling. In the Great Plains, Juniperus sp. have encroached large areas in Oklahoma (>3,000,000 ha), Texas, Kansas, Missouri, and Nebraska. Preliminary data from 2008-2010 indicated that a J. virginiana woodlands in north-central Oklahoma yielded less water than adjacent grassland watershed. We want to demonstrate that an integrated feedstock system in the southern Great Plains that includes Juniperus spp., native prairie vegetation, and dedicated feedstock production of switchgrass can be used to support the production of advanced liquid biofuels while improving water yield and quality. Harvest of biomass-dense stands of J. virginiana will restore ecosystem services of grasslands related to livestock forage and wildlife habitat. This will increase water yield by varying amounts based on conversion to native prairie versus managed switchgrass monocultures. By scaling our results to the landscape and region we will determine how regional land cover change resulting from
biofuel feedstock production affects water yield and quality, taking into account climate gradients. We will develop the necessary metrics and decision support tools for evaluating trade-offs between biofuel production, feedstock choices, and water yield and quality.

**Brief Summary of Project:** Our goal is to parameterize a water budget and evaluate water quality for an integrated feedstock production system consisting of *J. virginiana*, intensively cropped switchgrass, and extensively managed native grasslands. Specifically, we will 1) determine the impact of harvesting *J. virginiana* on water yield and quality at the watershed scale, as compared to restored native grasslands, 2) determine how planting switchgrass after *J. virginiana* harvest affects water quantity and quality and compare to native grassland recovery, and 3) scale results to the landscape and regional level, accounting for regional gradients in climate, as well as projected climate change. To accomplish these objectives, we will harvest *J. virginiana* from two of four encroached watersheds in central Oklahoma that have been stream gauged since 2009 and measure changes in water quantity and quality. We will establish switchgrass on one harvested watersheds and one of the existing grassland watersheds, contrasting water yield and quality of these planted areas to recovering as well as intact native herbaceous communities. Data will be scaled to the landscape and region to determine how land cover change affects water yield and quality, taking into account climate gradients and allowing for different potential mosaics of land-use.

**BIOENERGY LAND USE CHANGE IN THE U.S. MIDWEST AND THE BCAP LANDS**

Cuizhen (Susan) Wang, University of South Carolina; Felix B. Fritschi, University of Missouri; Ranjith Udawatta, University of Missouri; Claire Baffaut, USDA-ARS Cropping Systems and Water Quality Research Unit, and University of Missouri

This project explores an integrated approach to documenting land use conversion of perennial biomass crops using satellite time series and assessing its impacts on soil/water qualities in the Midwest. With the 8-day MODIS time series, a set of phenology metrics are extracted to delineate corn and warm-season tallgrasses from other land use/covers in the region. Corn boom was observed in 2007 but corn acreage dropped back to normal in 2008. A spatially constrained phenology-assisted unmixing approach was developed to extract crop percent covers in MODIS pixels with an overall RMSE range of 14-20%. In the BCAP lands (Project Area 1) of Missouri, an Enhanced Spatial and Temporal Adaptive Reflectance Fusion (STARFM) model is applied to perform data fusion between MODIS and Landsat imagery, which are used to extract warm-season grasses at improved accuracies and spatial details. In selected HUC 8-scale watersheds in the focus sites, field equipments are installed to continuously collect soil/water quality data. In next year, these field-measured and satellite-extracted data will be used to calibrate the Soil and Water Assessment Tool (SWAT) to assess soil and water quality in these watersheds as well as the whole region. This project provides spatially explicit insights for current and future land use patterns of energy crops and their environmental consequences in the U.S. Midwest.
CARBON SEQUESTRATION AND GREENHOUSE GAS EMISSIONS FROM SUSTAINABLE INTERCROPPING OF SWITCHGRASS AND HYBRID POPLAR FOR BIOENERGY PRODUCTION
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We will report the results from the 2014 growing season where hybrid poplars are intercropped or grown in monoculture with switchgrass at Boardman, OR.

LOBLOLLY PINE-SWITCH GRASS INTERCROPPING FOR SUSTAINABLE TIMBER AND BIOFUELS PRODUCTION IN THE SOUTHEASTERN UNITED STATES
John King, North Carolina State University

The poster will provide the rationale, objectives and hypotheses of a five year experiment to quantify productivity, water cycling, and soil C and N cycling of a novel loblolly pine – switchgrass intercropping system. The system is designed to provide traditional wood products and ligno-cellulosic feed stocks for biofuels/bioenergy production using traditional land management methods. Results to date/major findings will be presented after four years of growth, along with future plans for the remainder of the experiment, which is anticipated to end in 2016.

EFFECT OF BIOCHAR SOIL AMENDMENT ON SOIL C AND WATER DYNAMICS
Paul Adler, United States Department of Agriculture, Agricultural Research Service

The turnover of switchgrass (Panicum virgatum L.)-derived biochar C was evaluated in the laboratory using soil from four marginally productive sites in central Pennsylvania. Carbon dioxide emissions from unamended soil, biochar-amended soil, and pure biochar were monitored during 189-d incubations, and data were fit to a two-pool exponential model to estimate the amount and mean residence time (MRT) of C in labile and stable pools. Carbon-13 signatures of emitted CO2 were also determined to estimate the proportion of emitted CO2 derived from the biochar. Mixing biochar with each of the soils reduced the apparent MRT of C in both labile and stable pools, but the magnitude of change depended on the soil. Overall, the biochar was largely stable in each soil, with only 1.1 to 2.1% of the added biochar C emitted during incubation. There was no measurable effect of biochar amendment on the turnover of native SOM in any of the soils. Therefore, we conclude that amendment of our soils with switchgrass-derived biochar can effectively increase net C sequestration.
We asked whether the addition of biochar to soils could significantly increase the availability of water to a crop. Biochar made from switchgrass (Panicum virgatum L.) shoots was added at the rate of 1% of dry weight to four soils of varying texture, and available water contents were calculated as the difference between field capacity and permanent wilting point water contents. Biochar addition significantly increased the available water contents of the soils by both increasing the amount of water held at field capacity and allowing plants to draw the soil to a lower water content before wilting. Among the four soils tested, biochar amendment resulted in an additional 0.8–2.7 d of transpiration, which could increase productivity in drought-prone regions or reduce the frequency of irrigation. Biochar amendment of soils may thus be a viable means of mitigating some of the predicted decrease in water availability accompanying climate change that could limit the future productivity of biofuel crops.

IMPACTS OF BIOMASS SORGHUM FEEDSTOCK PRODUCTION ON CARBON SEQUESTRATION AND GREENHOUSE GAS EMISSIONS IN THE SOUTH CENTRAL REGION.
Frank M. Hons, Texas A&M University

Bioenergy (biomass) sorghum is a second-generation biofuel feedstock that has demonstrated wide adaptation and production advantages over other bioenergy crops in the southcentral US. Our preliminary studies showed that: 1) biannual rotation with corn increased sorghum biomass yield compared to sorghum monoculture, and 2) bioenergy sorghum systems yielded three times more biomass than similar corn-based systems, while sequestering more soil organic carbon (C) and total nitrogen (N). However, to fully exploit the potential benefits and to determine the environmental impacts of biomass sorghum feedstock production requires a better understanding of underlying mechanisms and soil processes.

Overall Long-Term Goal – To develop advanced biomass sorghum cropping systems utilizing improved nutrient management, rotation, and decreased soil disturbance, among other practices, to increase C sequestration, reduce greenhouse gas (GHG) emissions, and improve the sustainability of biomass sorghum feedstock production in the south central US.

Specific Objectives

1) Determine the effects of tillage, fertilization, biomass return, and crop rotation on sustainability, especially with regards to: a) quality and yield of biomass sorghum: b) C sequestration, soil quality, and nutrient cycling; and c) GHG emissions.

2) Elucidate how the above management practices alter C and N cycling and GHG emissions across varying soil types and climate,

3) Determine which combinations of integrated practices are most environmentally and economically sustainable based on a life cycle analysis (LCA) for C and net returns.
Field-based agricultural systems research is being used to study the effects of rotation, biomass removal, tillage, N addition, soil type, and climate on biomass sorghum yields, soil organic C (SOC), GHG emissions, net economic returns, and other properties of these systems. The project to develop management practices for biomass sorghum showed that in the near-term: 1) this crop can yield over 30 Mg of dry feedstock per hectare annually while sequestering more SOC than corn; 2) biomass sorghum depleted soil macronutrients more than corn; 3) sorghum can accrue over 3 Mg C ha-1 yr-1 in soil to a depth of 90 cm; 4) all bioenergy sorghum production systems studied resulted in net negative GHG emissions and exceeded federally mandated reduction goals; 5) crop rotation, fertilization, and biomass return reduce short-term biofuel feedstock production efficiency, but are recommended to minimize pest pressure and long-term soil quality impact. Former research at TAMU showed that excessive biomass removal significantly decreased subsequent biomass yield, SOC, and nutrient cycling. A negative outcome of biofuel production to address near-term problems (reliance on imported fossil fuels) may be creating or aggravating longer-term problems (reduction in the productive capacity of soils). To avoid this, the long-term net effects of biomass sorghum management practices on yield, SOC, GHG cycling, and economic sustainability must be determined. The systems approach incorporates direct measurement of GHG fluxes and SOC sequestration, with life cycle analyses for C, nutrients, and energy. Interrelationships between climate, soil and management factors are examined through modeling and analysis to predict the overall system's effect on C cycling, GHG emissions, and environmental and economic sustainability.

**ECOSYSTEM SCALE CARBON FLUXES AND EVAPOTRANSPIRATION OF BIOENERGY CROPS COMPARED TO CONVENTIONAL COTTON CROPPING SYSTEMS IN THE SOUTHERN GREAT PLAINS**

Nithya Rajan, Texas A&M University

Studying the energy and carbon exchange processes between land cover and the atmosphere is important in understanding the feedbacks between vegetation and climate. We investigated the impact of land use change from conventional cotton cropping systems to bioenergy crops on seasonal changes in net carbon dioxide exchange, evapotranspiration, and energy partitioning in the Southern Great Plains. Carbon dioxide and energy fluxes between the vegetation and atmosphere were measured using eddy covariance flux towers established in representative cropping systems, which included irrigated cotton (Gossypium hirsutum L.), dryland cotton, biomass sorghum (Sorghum bicolor L), and a perennial grassland (Old World Bluestem, Bothriochloa bladhii (Retz) S.T. Blake) field in 2013 and 2014. Our results indicate that net ecosystem exchange, ecosystem respiration, gross primary production, and evapotranspiration for these agro-ecosystems were strongly affected by environmental variables. The highest carbon uptake and was observed for the biomass sorghum field in both years. In 2013, the irrigated
cotton field had the highest evapotranspiration. In 2014, evapotranspiration was highest for the biomass sorghum field. As C4 plants, biomass sorghum and perennial grasses such as Old World Bluestem are adapted to surviving the hot, semi-arid climatic conditions of the Southwestern Cotton Belt region. The low carbon uptake in the grass field was primarily due to lack of irrigation. However, during the peak growing season of the grass, its carbon uptake was similar to the cotton field.

CHEMICAL COMPOSITIONS AND ENERGY CONVERSION OF PERENNIAL ENERGY CROPS GROWN IN THE SOUTHEASTERN US.

Sudhagar Mani, Hari Singh, Bharat Singh, Upendra Sainju, and William Anderson

Fort Valley State University

Energy crops such as napiergrass, energy cane can be a potential high yielding biomass for generation of biomass. Chemical compositions and fuel properties of perennial energy crops grown from six fertilizer treatment plots were evaluated for the past three years (2011, 2012 & 2013) and compared the consistence and variability among treatments and year of harvesting. In order to improve handling, transport and storage characteristics of energy crops for energy production, energy crops were pelletized to evaluate the quality attributes such as pellet density, hardness, durability and stability of energy crop pellets. Napiergrass, energy cane (whole), energy cane and sweet sorghum bagasse (after sugar extraction) were obtained from Fort Valley State University and were size reduced using a hammer mill to suitable particle size and densified into pellets using a laboratory scale pellet mill. Among four feedstock studied, napiergrass produced the highest quality pellets in terms of bulk density, hardness and durability. Higher hardness value was also related to higher durability for efficient handling, transport and storage. In this project, pyrolysis characteristics of napiergrass, and energy cane grown in the Southeastern US were investigated. Pyrolysis of energy crop samples was conducted using a batch pyrolysis reactor at 500°C for one hour. The yields of biochar and bio-oil from each energy crop were determined. The chemical compositions and fuel characteristics of bio-oil and biochar samples were determined and compared. The quality of bio-oil was evaluated by determining the water content, pH, chemical compositions and compared with pyrolysis oil produced from pine wood chips. A qualitative measurement of oil composition was determined using a GC-MS to evaluate its potential to produce drop-in biofuels. Finally, a life cycle assessment framework is under development to evaluate the sustainability of perennial energy crops produced in the southeastern US.
A requirement for NIFA grantees is to report on an annual basis the progress and accomplishments of their project. Once the project has come to an end it is also a requirement to submit a final termination report. This report should cover the entire period of the award.

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When writing your final termination reports please keep in mind the following points. If some of the points don’t fit within the REEport reporting system, additional material can be sent to the National Program Leader.

- Outputs are things you do, such as: activities, events, services, products, people reached. Outputs help link what you do with the project impact. Outcomes/Impacts answer the question “What happened as a result of my project”? It creates a change in knowledge, actions or conditions.

- Outcomes/Impacts sometimes are seen in a long-term and not during the period of the grant. We encourage the submissions of these outcomes. They can be directly sent via e-mail to the National Program Leader. This information may include but not limited to: published manuscripts, presentations, developed workshops, press releases, news releases, significant findings, newly developed technology, people benefited from the project and other communications that are critical for the success of our program.

- What benefit has come from your work? Provide answers to this question in terms that will be meaningful to congressional leaders, community leaders, taxpayers, farmers, and other researchers. Because you, as an agricultural scientist, are accustomed to communicating in technical terms about details of your work, this will require stepping back to consider a broader perspective. You will likely need to translate results of your study from scientific terms to lay terms – things that everyday people can relate to. For example, when deciding what impact to report, you might consider changes in: Economics, Community, Environment, Agricultural practices, Scientific knowledge.

- If you have knowledge of publications that were cited as a result of your projects, please include this information as well.

- If your project didn’t go as expected, we would like to know the circumstances that created change or failure. If you had to do it over again, what would you have done differently in your project during the funding period?

- What were the major challenges you or your organization faced during the grant period?
Appropriate Acknowledgment of Your Award

The Agriculture and Food Research Initiative (AFRI) plays an essential role in fulfilling the mission of the National Institute of Food and Agriculture. Proper acknowledgment of your USDA-NIFA-AFRI funding in published manuscripts, presentations, press releases, and other communications is critical for the success of our agency’s programs. This includes proper acknowledgment of the program and agency, as well as that of the Department and grant number.

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