cenusa bioenergy

Annual Progress Report

Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform

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NOTICE

This quarterly report was prepared by Iowa State University and CenUSA Bioenergy research colleagues from Purdue University, United States Department of Agriculture-Agricultural Research Service, University of Illinois, University of Minnesota, University of Nebraska, Lincoln, University of Vermont, and the University of Wisconsin in the course of performing academic research supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA).

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Executive Summary – CenUSA Bioenergy

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 from these biofeedstocks based on pyrolytic conversion is being evaluated. Objectives of the project are to: 1) develop cultivars and hybrids of perennial grasses optimized for bioenergy production, 2) develop sustainable production systems that optimize perennial biomass yields and ecosystem services, 3) develop flexible, efficient, and sustainable logistics systems, 4) identify and characterize sustainable bioenergy systems to achieve social, economic, and environmental goals and understand socioeconomic and environmental consequences of perennial bioenergy systems, 5) identify germplasm characteristics amenable to pyrolytic conversion and evaluate performance of pyrolytic biofuels, 6) evaluate policy, market, and contract mechanisms to facilitate broad adoption by farmers, 7) develop procedures for managing risks and protecting health for each component of the biofuel production chain, 8) provide interdisciplinary education and engagement opportunities for undergraduate and graduate students, and 9) develop outreach programs for all stakeholders of the bioenergy system.

The second year of the project, described in the following report, was extremely productive in terms data collection, education and outreach activities. Moreover, this second year was characterized by significant transdisciplinary interactions across objective areas. The composition of the leadership team (co-project directors) and collaborations is highly diverse representing a network of eight institutions - Iowa State University, Purdue University; University of Wisconsin, Madison; University of Minnesota, Twin Cities; University of Nebraska, Lincoln; University of Illinois, Champaign; University of Vermont-Burlington; and the USDA's Agricultural Research Service and several research disciplines including plant breeding and genetics, crop ecology and management, ecology, systems modeling, economics, biological systems engineering, mechanical engineering and education and extension. Each of the program areas contributes materially and otherwise to the work being conducted by other objective teams. For example, Objective Area 1 (Feedstock Development) is highly integrated with the activities of other areas. In the past project year, they provided seed to Objective Areas 2 (Feedstock Production), 3 (Feedstock Logistics), and 9 (Extension and Outreach). The Project Directors for Objective Area 1 participated fully in education activities developed by our Education and Extension Objective Areas (8 and 9, respectively). Ken Vogel, Co-Pd and co-leader of the Feedstock Development Team, provided two days of instruction for the Intensive Program for graduate students organized by the Education Team and Mike Casler, the other Co-Pd from Feedstock Development organized *Switchgrass II* a three-day workshop that covered the state-of-the-art in native warm-season grass research and production. Student travel to this meeting was subsidized in part through travel scholarships made available through the Education Objective.

Many other interactions occurred within and across objective areas. Rob Mitchell Co-Pd for Feedstock Production (Objective 2), was extremely active in facilitating the establishment of field studies across the fourteen sites under study in that objective. He was also very active in providing educational materials for Education, and providing technical support and training for Extension. It became apparent during the Annual Meeting in Lincoln Nebraska that Objective Areas 4 and 6 had goals that while not the same, required similar approaches. Since that time they have met and actively worked together on research of common interest. There are many other examples of active collaboration and interaction among the diverse disciplines encompassed by the CenUSA team which are described more fully in the sections that follow.

Another important development occurring in year two was the active engagement that occurred with commercial partners in the thermochemical conversion industry. Although such engagement was not part of our original scope, we were encouraged by our National Program Leader to develop more active relationships with companies that would be involved in the commercialization of the technologies we are working one. The first step in this process was to organize a workshop entitled **Roadmap to Commercialize Thermochemical Biofuels and Bio-Products Processing in the Midwest** that was held December 11-12, 2012 at Iowa State University. The workshop was well attended by industry representatives who fully participated in presentations and discussions. The workshop focused on optimal feedstocks and commercial pathways and had three primary goals: 1) fostering relationships between CenUSA researchers, Midwest agricultural producer groups, and the thermochemical processing industry; 2) identifying optimal biomass feedstock characteristics for thermochemical processing of biomass; and 3) identifying commercial pathways for thermal chemical processing of herbaceous biomass to in the Midwest region. A full report on the workshop and its outcomes is included in an exhibit attached to this report. However, a very important and valuable result is the initiation of ongoing collaboration with three of the companies that were in attendance.

A summary of the activities, outcomes, and deliverables from each of the Objective Areas follows below. More details are included in the comprehensive report that commences in the next section.

Executive Summary – Feedstock Development Objective

The Feedstock Development objective focuses on developing perennial grass cultivars and hybrids that can be used on marginal cropland in the Central United States for the production of biomass for energy.

Co-Project Directors

- Ken Vogel, USDA Agricultural Research Service - Northern Plains.
- Mike Casler, U.S. Dairy Forage Research Center. michael.casler@ars.usda.gov / (608) 890-0065

Accomplishments – Year 2

CenUSA funding enabled the ARS breeding projects at Lincoln, Nebraska and Madison, Wisconsin to complete a third year of testing of previous established yields tests in three Midwest states.

- **Breeding for Biomass Yield in Switchgrass**

  - Selection and breeding within WS4U upland switchgrass increased biomass yield by 4% per year for a simple phenotypic recurrent selection program that required only two years per generation.

  - Selection for biomass yield and winter survival within Kanlow lowland switchgrass increased biomass yield by 2% per year.
  - Selection for biomass yield and winter survival within Kanlow x Summer hybrid populations resulted in third-generation populations with superior biomass yield and survivorship across HZ3 through HZ5, combining the best traits of both the upland and lowland parents. On average, the hybrid populations had 43% higher biomass yield than the better of the two parents, regardless of the location.

  - All of the gains in biomass yield were associated with increases in biomass quality traits on a per-hectare basis, e.g. higher yield of ethanol per hectare and more combustible energy produced per hectare.

- **Integrated Project Impact**
  - A journal paper on switchgrass selection criteria for biomass yield was accepted for publication in *Crop Science* (Mike Casler – ARS Madison): Price, D.L. and M.D. Casler. 2013. Predictive relationships between plant morphological traits and biomass yield in switchgrass. *Crop Sci*. (in press).

  - Two journal papers on inheritance of secondary traits affecting yield in switchgrass have been submitted for publication and are currently in journal review (M. Casler, ARS-Madison): Price, D.L. and M.D. Casler. 2013. Inheritance of secondary morphological traits for among-and-within-family selection in upland tetraploid switchgrass. *Crop Sci.* (in review) and Price, D.L. and M.D. Casler. 2013. Divergent selection for secondary traits in upland tetraploid switchgrass and effects on sward biomass yield. BioEnergy Res. (in review).

- **New Switchgrass Crossing Procedure**

  A new switchgrass crossing procedure was developed and evaluated for improving seed yield from matings of individual plants in the greenhouse (Ken Vogel, ARS Lincoln).

Planned Activities, Outcomes and Impacts – Year 3

- New switchgrass cultivar released. This cultivar will be first lowland biomass type switchgrass that is fully adapted to the Midwest. Journal Registration paper submitted.
- Methods paper on improved method for making specific crosses with switchgrass and other perennial grasses submitted.
- Summary report on variation among and within laboratories using different analytical systems for mineral element composition of switchgrass biomass. Journal paper submitted.
- Seed of new experimental strains (potential breeder seed) of switchgrass, indiangrass produced for use in second set of yield tests.
- Summarized identification of potential arthropod pests and beneficial arthropods (predators, parasitoids, decomposers, pollinators) associated with switchgrass and other bioenergy grasses. Summary published.
- Summarized characterization of the seasonal abundance of selected arthropod pests.
- Evaluation of over 50 switchgrasses and other bioenergy grasses for susceptibility/resistance to aphids.
- Summarized results on the genetic variation in switchgrass upland and lowland populations for field tolerance or resistance to viruses and quantification of their effect on biomass yield in switchgrass.
- Summarized results on the relationship between switchgrass biomass composition and pyrolysis product yields for switchgrass strains/families known to be genetically different for lignin and ash concentration.
- Identification of viral and fungal foliar pathogens infecting experimental switchgrass strains and cultivars in regional trials.

Executive Summary - Sustainable Feedstock Production Systems Objective

This CenUSA Bioenergy objective focuses on conducting comparative analyses of the productivity potential and the environmental impacts of the most promising perennial grass bioenergy crops and management systems using a network of 14 fields strategically located across the Central United States. The goal is to produce a quantitative assessment of the net energy balance of candidate systems and optimize perennial feedstock production and ecosystem services on marginally productive cropland while maintaining food production on prime land.

Co-Project Directors

- Jeffrey Volenec, Purdue University. jvolenec@purdue.edu / (765) 494-8071

- Robert Mitchell, USDA-ARS. Rob.Mitchell@ars.usda.gov / (402) 472-1546

- David Laird, Iowa State University. dalaird@iastate.edu / (515) 294-1581

Major Accomplishments – Year 2

Seed Factor Analysis Plots and Systems Analysis Plots have been re-established in Iowa, Illinois, Indiana, Minnesota, and Nebraska. Soil samples have been secured and analyzed. Plots have been fertilized based on soil test recommendations. Weed competition has been monitored and necessary control measures implemented. Where possible, environmental measurements have started, including greenhouse gas (GHG) measurements.

Planned Activities, Outcomes and Impacts – Year 3

- Monitor growth of newly established perennial System and Factor Plots and intervene as necessary with management tools to aid establishment.

- Continue to monitor weed pressure and establishment and use control measures as necessary.

- Continue soils analysis for nutrients and carbon.

- Where possible, install necessary equipment and begin environmental measurements, including GHG concentrations.

- Analyze tissues for NDF, ADF, ADL, and calculate concentrations of cellulose, hemicellulose, lignin, ash, and other constituents. Analyze biomass and where reserve storage is of interest analyze overwintering tissues for starch, sugars, proteins and amino acid N. Where soil fertility is a management input of interest analyze tissues for N, P, K, and other mineral constituents.

- Harvest plots for biomass at or near the killing frost for each location, and calculate yields.

- Conduct statistical analysis of data.

- Prepare annual reports of data for GHG emissions, biomass production, surface soil characteristics, and management.

- Continue to improve biophysical models by calibrating SWAT and APEX with data from the biophysical measurements.

Executive Summary - Feedstock Logistics Objective

The Feedstock Logistics Objective focuses on developing systems and strategies to enable sustainable and economic harvest, transportation and storage of feedstocks that meet agribusiness needs. The team also investigates novel harvest and transport systems and evaluates harvest and supply chain costs as well as technologies for efficient deconstruction and drying of feedstocks.

Co-Project Directors

- Stuart Birrell. Iowa State University. sbirrell@mail.iastate.edu / (515) 294-2874
- Kevin Shinners, University of Wisconsin-Madison kjshinne@wisc.edu / (608) 263-0756

Major Accomplishments – Year 2

We modified a baler to accumulate and strategically place bales at harvest. We have completed our field time and motion studies on strategic bale placement to reduce costs associated with aggregating bales. Strategic bale placement significantly reduced time, distance, and fuel consumption compared to random bale placement, but the benefits were reduced as crop yield and number of bales per acre increased.

We have quantified energy requirements for size reducing perennial grass biomass. Overall energy expenditures were less when material was size-reduced at harvest by a forage harvester compared to the traditional approach of baling and post-storage grinding. However, bale grinding throughput and fuel consumption was significantly improved when bales were pre-cut (i.e. gross size-reduced) at baling.

We have configured a biomass mower to combine four unit operations in a single pass: (1) cutting, (2) conditioning, (3) intensive re-conditioning, and (4) tedding. The combination of these four unit operations, completed in a single pass, reduced the drying time of fall-harvested switchgrass from three to two days.

We have finished one year of study on the outdoor storage characteristics of round bales. Wrapping bales in a tube of thin layer stretch plastic produced storage losses that were statistically similar to bales stored indoors. No other approach to outdoor storage was as effective at conserving biomass value as these two methods.

Planned Activities, Outcomes and Impacts – Year 3

Work will continue to:

- Quantify the energy required to size-reduce perennial grass biomass at harvest and post-storage;
- Economically reduce outdoor storage losses; and
- Confirm the performance of the single-pass multi-operation mower to improve the drying rate of perennial grasses

In addition, we will conduct modeling work to optimize the relationship between crop yield, bale size and strategic bale placement. New efforts will also be directed towards developing standardized modules of compacted biomass that has been size reduced at harvest. Material will also be provided to cooperators to evaluate conversion efficiency and biochar quality.

Executive Summary - System Performance Metrics, Data Collection, Modeling, Analysis and Tools Objective

This research team focuses on providing detailed analyses of feedstock production options and an accompanying set of spatial models to enhance the ability of policymakers, farmers, and the bioenergy industry to make informed decisions about which bioenergy feedstocks to grow, where to produce them, what environmental impacts they will have, and how biomass production systems are likely to respond to and contribute to climate change or other environmental shifts.

Co-Project Directors

- Jason Hill, University of Minnesota, Twin Cities. hill0408@umn.edu / (612) 624-2692
- Cathy Kling, Iowa State University. ckling@iastate.edu / (515) 294-5767

Accomplishments – Year 2

We have completed in-depth testing of the Upper Mississippi River Basin (UMRB) and Ohio-Tennessee River Basin (OTRB) SWAT models and an initial manuscript is under review. We are preparing to run a series of scenarios using the model to consider the water quality consequences of widespread adoption of biofuel crops, especially switchgrass. We have received a new version of the EPIC model that features an entirely new soil carbon cycling submodel (along with the GHG emission algorithms). The EPIC model will be integrated with the SWAT model of the UMRB and OTRB in order to study greenhouse gas effects associated with widespread adoption of switchgrass.

Planned Activities, Outcomes and Impacts – Year 3

- **Iowa State University**

  In Year 3, the ISU team will complete the adaptation of existing biophysical models to represent second-generation biofuel crops and begin analysis of specific watersheds. We will begin with the Raccoon River Watershed in Central Iowa where we will develop an empirical Pareto frontier for the Boone River Watershed, an agriculturally dominated watershed, to demonstrate the tradeoffs between food, fuel, and water quality gains from a range of switchgrass placements within the watershed. This empirical frontier will allow explicit consideration of policy-focused questions including:

  - Does the restriction to grow switchgrass on marginal land correspond to the first best allocation of land within a watershed?

- What tradeoffs does such a restriction imply between water quality, food, and fuel production?

- How do the answers to these questions change as the degree of agglomeration economies change or the relative price of fuel increases?

Scenarios related to climate change and to the larger watershed region of the Upper Mississippi River Basin and Ohio-Tennessee will also started during Year 3.

- **University of Minnesota**

  In Year 3, the University of Minnesota team's work will include Task 1 - Adapt existing biophysical models to best represent data generated from field trials and other data sources, Task 2 - Adapt existing economic land-use models to best represent cropping system production costs and returns, Task 3 -Integrate physical and economic models to create spatially-explicit simulation models representing a wide variety of biomass production options, and Task 4 - Evaluate the lifecycle environmental consequences of various bioenergy landscapes.

  Specific activities will include further investigation into switchgrass yield gaps, landscape-level estimation of ecosystem services using the InVEST model, and lifecycle modeling of the biofuels pathways being considered in this grant.

Executive Summary - Feedstock Conversion and Refining: Thermo-chemical Conversion of Biomass to Bio-fuels Objective

The Feedstock Conversion and Refining objective will perform a detailed economic analysis of the performance of a refinery based on pyrolytic processing of biomass into liquid fuels and will provide biochar to other CenUSA researchers. The team concentrates on two primary goals:

- Perform technoeconomic analysis of converting grass crops into fuel via pyrolysis.

- Preparing and characterizing Biochar for agronomic evaluations.

Co-Project Director

- Robert Brown, Iowa State University. rcbrown3@iastate.edu/ (515) 294-7934

Major Accomplishments – Year 2

Objective 5 CoPd Robert Brown has delivered two CenUSA webinars: *2013 - Thermochemical Conversion of Biomass to Drop In Biofuels* (http://www.youtube.com/watch?v=Ua8She55qTc) and *Thermochemical Option: Thermochemical Conversion of Biomass to Fuel* (June 2012). http://www.youtube.com/watch?v=6dkV9OKw2F8.

Through the second quarter of year 2, the Feedstock Conversion objective's overall accomplishments are on track to meet project goals. In Year 1, the decision was made to use long-term biochar field plot trials to quantify the stability of biochar C and C sequestration potential of biochar as noted in previously submitted progress reports. The field plot studies have the advantage of providing realistic field environments, but are limited in the number of biochars that can be studied. Laboratory incubations are being used to compare the relative stability of different biochars.

Planned Activities, Outcomes and Impacts – Year 3

- **Task 1. Perform Technoeconomic Analysis.** We will collect pyrolysis data from the Boateng group (Objective 1. Feedstock Development) and add these inputs to the pyrolysis process models finalized in Year 2. Additionally, a process model for mild catalytic pyrolysis will be finalized. Mild catalytic pyrolysis experimental data collected at ISU will be used to estimate impacts to product distribution and yield compared to those from traditional pyrolysis. For both cases complete mass and energy balances will be developed, and capital and operating expenditures will be determined. The internal rate of return (IRR) and net present value (NPV) of pyrolysis and mild catalytic based biorefineries will also be calculated. A sensitivity analysis will be conducted to determine the process variables that have the greatest impact on overall cost of the system.

  Task 2. Prepare and Characterize Biochar. We will continue efforts to optimize **thermochemical** treatments for the production of high anion exchange capacity (AEC) biochars along with spectroscopic, chemical, and x-ray diffraction investigations of the structure and properties of high AEC biochars. Bulk quantities (~1 kg) of the currently best available high AEC biochar will be produced. The high AEC biochar will be used in a greenhouse pot study to assess the impact of high AEC biochar amendments on nitrate and phosphate leaching and plant growth under both alkaline and acidic soil pH conditions.

Executive Summary - Markets and Distribution Objective

The Markets and Distribution objective recognizes that a comprehensive strategy to address the impacts to and requirements of markets and distribution systems will be critical to the successful implementation and commercialization of a regional biofuels system derived from perennial grasses grown on land unsuitable or marginal for the production of row crops. To create this comprehensive strategy the team focuses on two unifying approaches:

- The study and evaluation of farm level adoption decisions, exploring the effectiveness of policy, market and contract mechanisms that facilitate broad scale voluntary adoption by farmers; and

- Estimate threshold returns that make feasible biomass production for biofuels.

Co-Project Directors

- Dermott Hayes, Iowa State University. dhayes@iastate.edu / (515) 294-6185

- Keri Jacobs, Iowa State University. kljacobs@mail.iastate.edu / (515) 294-6780

Major Accomplishments – Year 2

- **Marginal land definition**. We continue to explore placement scenarios for switchgrass on the landscape in collaboration with researchers and scientists in the CenUSA *System Performance Metrics* objective (Objective 4).

- **2012 Integrated Crop Management Conference and Survey**. As a means of identifying the barriers and drivers of implementation of the biomass production system, our team arranged to participate in an Integrated Crop Management (ICM) extension series in December 2012. A survey was administered to session participants to gain feedback for our modeling efforts. The survey results have been integrated in a report, *Drivers and Barriers to Perennial Grass Production for Biofuels* (See Exhibit 11, *Adoption of Switchgrass Production Survey*).

- **Spatial model of biomass supply**. Previous studies of cost of production of switchgrass in the region have been collected and updated to provide the cost basis needed for producer decision making. Further analysis will estimate the effects of region, variety, weather, plot size, etc., on yields obtained. This analysis will be conducted in collaboration with Rob Mitchell and Ken Vogel who are working on objectives 1 (Feedstock development) and 2 (Sustainable feedstock production systems).

- **Modeling the aggregate supply curve for switchgrass, wheat straw, and corn stover**. Dermot Hayes continues to work on the regional supply curve for grasses and corn stover using a real options framework. This work is expected to be ongoing.

Planned Activities, Outcomes and Impacts – Year 3

In Year 3 the Markets and Distribution objective anticipates using data made available by other CenUSA objectives as input into our modeling efforts. The following specific tasks will be pursued:

- **Task 2. Perrin (UNL)** will estimate threshold returns that make feasible biomass production for biofuels based on input costs and output price scenarios, and on-farm benefits to nearby and adjacent row crop systems. Perrin's work is expected to result in a report that summarizes recent and relevant related work on biomass production and also provides implications of these findings on this project. This work will aid in the ongoing modeling efforts in tasks 3 and 4. This is work ongoing from Year 2 and we expect to complete this during Year 3.

- **Task 3. Jacobs (ISU)** with input and expertise from Hayes (ISU) and Perrin (UNL) will develop the set of market, contract and policy mechanisms necessary to make optimal and sustainable the production of biomass feedstock on the identified lands. We will use data and activity outcomes from this and other Objectives, including projected costs and threshold returns to biomass production and returns to alternative and current land uses. These mechanisms will be evaluated on their flexibility and propensity to improve the voluntary adoption of a sustainable production system. This task spans three project years. Note: there is no expectation for an output in year 3.

- Task 4. Jacobs (ISU) will develop a decision model to predict the likelihood that the targeted land identified within Objective 4 will be used for perennial biomass crop production, accounting for returns to biomass and row crop production, market conditions and policy and contract incentives and mechanisms. As this task spans 4 project years, there is no expectation for an output in year 3.

- Task 5. Hayes (ISU) will use existing national and global agricultural policy simulation models that endogenize prices (Meyers *et al.* 2010; Hayes *et al.* 2009; Du and Hayes 2009), to estimate scale effects of bio-energy production on national and international commodity markets and greenhouse gas (GHG) on regional and global food, feed, fiber and energy systems both with and without indirect land use impacts using the Food and Agricultural Policy Research Institute (FAPRI) model (Searchinger *et al.* 2008; EPA 2010).

- Task 6. Hayes (ISU), in collaboration with investigators from the System Performance objective (Objective 4) will develop an alternative procedure to conduct lifecycle analysis (LCA) that accounts for the opportunity cost of land. The new procedure will be coupled with the traditional LCA approach to evaluate system wide GHG impacts of alternative production systems.

Executive Summary - Health & Safety Objective

The production of bioenergy feedstocks will have inherent differences from current agricultural processes. These differences could increase the potential for workforce injury or death if not properly understood and if effective protective counter measures are not in place. The Health and Safety team addresses two key elements in the biofuel feedstock supply chain:

- The risks associated with producing feedstocks; and

- The risks of air/dust exposure.

Co-Project Directors

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- Chuck Schwab, Iowa State University. cvschwab@iastate.edu / (515) 294-4131

Major Accomplishments – Year 2

More items have been added to the list of identified duties and responsibilities for determining the risk involved. Refinement in the group methodology is being considered because of the different types of individual tasks connected with duties and responsibilities associated with producing feedstocks.

After first examining preliminary injury data sources for establishment tasks to be used in the risk assessment, a change in the procedure of measuring the risk was needed because of the lack of specific data required for analysis.

Curtis Fielder, a new Ph.D. graduate student, joined our team. He will be working primarily on the risk analysis for tasks associated with producing biofeedstocks. The team has also established a cooperative arrangement with Dennis Murphy the investigator at Penn State University who is also working with another biofuel CAP project to collaborate in developing a standard to assess risk. The plan is to co-author some presentations and papers.

Good progress in refining the accumulated listing of tasks/responsibilities was made. Criteria for comparisons of risk assessments for handling the evaluation of the various tasks were begun and the standard risk assessment tool to use for tasks in biofeedstock production is still being constructed.

The Health and Safety team participated in the CenUSA eight-week internship program by hosting Ms. Carly Dutkiewicz from DePauw University.

Planned Activities, Outcomes and Impacts – Year 3

- We will continue the refinement of our baseline assessment of potential hazards.
- The pilot data for aerosols will be available in Year 3 allowing us to begin that portion of our work.
- We will continue to develop education modules in collaboration with the Education Objective and the Outreach and Extension Objective.
- New collaborators at Penn State University (another USDA NIFA bioenergy project) will be combining efforts in this direction to help define an industry standard for assessing risk and safety components.

Executive Summary – Education Objective

The Education Objective seeks to meet the future workforce demands of the emerging Bioeconomy through two distinct subtasks, as follow:

- To develop a shared bioenergy core curriculum for the Central Region, and

- To provide interdisciplinary training and engagement opportunities for undergraduate and graduate students.

Co-Project Directors

- Patrick Murphy, Purdue University. ptmurphy@purdue.edu / (765) 494-1175
- Raj Raman, Iowa State University. rajraman@iastate.edu / (515) 294-0465

Major Accomplishments – Year 2

- **Undergraduate Internship.** Nine undergraduate students were placed at CenUSA partner institutions: Iowa State University (5 interns); University of Nebraska, Lincoln (2 interns); University of Minnesota (1 intern); Idaho National Lab (2 interns) from May 29 – August 2, 2013.
- The first Native Perennial Grass Bioenergy Intensive Program was held at Iowa State University from June 6-18, 2013.
- **Began the online graduate research seminar series seminars.** The seminar series *required students to explain how their research fits into the broader goals of the project*, thereby creating a transdisciplinary-learning environment for graduate students involved in the project.

Planned Activities, Outcomes and Impacts – Year 3

- **Develop 20 course modules with stand-alone content.** Modules will be integrated into existing graduate and undergraduate courses at partner institutions and will also be packaged for delivery by distance education. Course module development will be linked with Extension module development in collaboration with the Outreach and Extension Objective to exchange content and repurpose modules for high school and community college agriculture programs.
- **Continue the summer internship program.** In 2012, the program hosted a diverse group of 11 students from across the country; 10 were accepted into the 2013 cohort. Overall responses to the 2012 program were extremely positive, in part due to formal mentoring training that we provide via podcast.
- During the academic year, six (three fall, three spring) online graduate seminars will continue to be held.

Executive Summary - Extension and Outreach Objective

The Extension and Outreach objective serves as CenUSA's link to the larger community of agricultural and horticultural producers and to the public-at-large.

Co-Project Directors

- Jill Euken, Iowa State University. jeuken@iastate.edu / (515) 294-6286
- Sorrel Brown, Iowa State University. sorrel@iastate.edu / (515) 294-8802

Major Accomplishments – Year 2

The Extension and Outreach Objective engaged in significant public contact through both public hosted events, virtual public events and in publications. The **Extension Staff Training/eXtension Team** hosted two webinars 1) "Discovery of Aphid Resistance in Perennial Bioenergy Feedstock" and "An Overview of Switchgrass Diseases."

The **Producer Research Plots/Perennial Grass Team** hosted a field day in Indiana and gave a presentation at the 4-H Energy Academy and the Purdue Energy Academy.

The **Public Awareness/Horticulture/eXtension 4-H and Youth Team** hosted events and created an "app" — the C6 iPad app for use at the 2013 Iowa State Fair.

The Broader Public education/Master Gardener Iowa team hosted a Master Gardener Summer Session Field Day at the Horticultural Station near Gilbert. The Minnesota Master Gardener team augmented its test plot locations to include a new biochar teaching garden at the Fond du Lac Tribal Community Center near Cloquet Minnesota. The team also been blogging via the National Master Gardener (eXtension) blogging platform.

The **Evaluation/Administration Team** helped host the *Workshop: Roadmap to Commercialize Thermochemical Biofuels and Bio-Products Processing in the Midwest* and has been instrumental in the planning of the joint meeting with the *Mississippi River Gulf of Mexico Watershed Nutrient Taskforce* scheduled for September 2013.

Planned Activities, Outcomes and Impacts – Year 3

- 75 extension educators and industry professionals will gain awareness and knowledge in bioenergy topics and will incorporate bioenergy-learning activities into their educational/outreach activities.
- We plan to hold a national workshop to be held in September 2014 for extension educators and other outreach professionals to provide training regarding bioenergy production, processing, and economics.
- We anticipate that 1,000 producers, industry leaders, educators, and agency personnel, and 300 horticultural producers and industry leaders will gain awareness and knowledge regarding environmental, economic, and public relations impacts of transitioning marginal

cropland to perennial grass. They will also understand the impacts of biochar as a soil amendment.

- We will hold 20 educational meetings, conferences, workshops, field days, media events, eXtension bioenergy learning modules, webinars, and networking activities regarding perennial biomass production BMPs; biomass logistics, safety, processing, economics; and BMPs for biochar as a horticultural soil amendment.

- We will establish and utilize a "citizen science" program to promote shared learning about the impacts of perennial grass agriculture on ecosystems; and we will promulgate best management practices (BMPs). The program will include the following outcomes:

- Farmers will participate in eight ongoing on-farm perennial biomass feedstock production demonstrations.

- We will hold four on-farm perennial crop field days.

- Nursery, turf, and landscape stakeholders will participate in seven community/public garden biochar demonstration plots.

- **Activities Targeted to Youth**.

    - Adult facilitators will conduct youth citizen science garden projects.

    - A cadre of "Junior Master Gardeners" will utilize perennial plants and/or biochar.

    - We will develop and host a new series of youth science camps for students related to bioenergy.
    - We will produce five learning modules for youth re: perennial grasses, carbon cycling, and biochar utilization.

- We will engage bioprocessing and agricultural industry and environmental leaders in CenUSA activities to facilitate exchange of information.

Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (AFRI-CAP 2010-05073)
2012 Annual Progress Report: August 1, 2013 – July 31, 2013

PROJECT ADMINISTRATION

1. Project Organization and Governance Accomplishments

CenUSA Bioenergy ("CenUSA") Project Director Ken Moore continues to lead the CenUSA research effort. Chief Operating Officer Anne Kinzel and Financial Manager Val Evans handle all CenUSA project administration and business affairs, including project coordination, communication, and data sharing among institutions across the states. Kinzel is responsible for the day-to-day project management and the planning and preparation of reports, meetings, data management, and maintenance of the project's public face. Evans is responsible for all project financial activities, including the development and implementation of administrative policies and procedures to ensure effective financial operation and oversight of the project.

- **Project Progress**

Each of the nine CenUSA objectives is showing very good progress towards meeting the project's timelines and deliverables schedules (See Exhibit 1. CenUSA Bioenergy Timelines and Deliverables). This past year has seen a number of important events and discoveries take place, all of which are covered in detail in this report. In addition, CenUSA successfully reapplied for Year 3 funding. A $5,000,000 award has been received (See Exhibit 2. Year 3 Year 3 NIFA Award 2011-68005-30411). CenUSA will reapply for Year 4 funding on about May 2014.

- **Advisory Board**

The Advisory Board consists of 12 members representing all links in the supply chain including biomass cultivar development and seed production and marketing, crop production, transportation, storage, conversion, marketing, environmental impacts, safety, and education are now represented on the Advisory Board (See Exhibit 3. CenUSA Bioenergy Advisory Board Roster). Advisory Board chair Tom Binder has been very diligent in attending the monthly CenUSA executive team meetings. Advisory board members have attended the monthly graduate seminars as well.

In September 2012, Bryan Mellage joined the Advisory Board, replacing Ben Steffen, also and agricultural producer, who was unable to free up enough time to participate in CenUSA activities. Mr. Mellage is a producer and agricultural implement dealer from Auburn, Nebraska with over 30 years experience in the agriculture and implement industries. Mr. Mellage has a very strong interest in biofuel and biomass energy farming.

In December 2012 board member Tim McCoy submitted his resignation. Due to a promotion he believed he was unable to devote sufficient time to CenUSA activities. McCoy, as a leading official at the Nebraska Game and Parks Commission, was our wildlife expert on the Board. At McCoy's suggestion we invited Eric Zach, Ag Program Manager at the Nebraska Game and Parks Commission to join the Board. Zach, who also has an extensive background Midwestern wildlife management agreed to join the Board in late January 2013.

- **Coordination, Collaboration, and Communication**

✓ **2013 Annual Meeting.** The 2013 Annual Meeting was held July 29 – August 1, 2013, at Purdue University in West Lafayette, Indiana (See Exhibit 4. 2013 Annual Meeting Agenda). Jeff Volenec, co-project director of the CenUSA *Sustainable Feedstock Production Systems* objective, hosted the meeting.

Over 80 people attended the meeting, including seven of 12 Advisory Board members and Donal Day, the project director for the Sustainable Bioproducts Initiative (SUBI) CAP project located at the Louisiana State University AgCenter.[1] The breakdown of attendees is shown in Table 1 and in Exhibit 5. Annual Meeting Participant List.

Table 1. 2013 CenUSA Annual Meeting	
CenUSA Collaborators	49
Advisory Board	7
Guests (CAP Director, Research Consultants, Post Doc., Visiting Undergrad. Scholar)	6
Graduate Students	12
Undergraduate Interns	9

Each of the nine research objective research teams provided progress reports to update CenUSA colleagues and guests. There was ample time for question and answer exchanges in all the sessions. As was the case in the two previous annual meetings, Advisory Board members participated actively in the meeting and provided valuable feedback to the participants. There was also time for each of the research objectives to meet and discuss Year 3 activities and to make further plans for Year 3 and beyond.

One entire morning was spent touring Purdue University's CenUSA involved facilities including the:

[1] More information about the SUBI project is available at https://www.lsuagcenter.com/en/crops_livestock/crops/Bioenergy/biofuels_bioprocessing/subi/

- Purdue University Water Quality Field Station
- Throckmorton-Purdue Agricultural Center

Photo 1. 2013 Annual Meeting Field Tour Purdue University Test Plot. The plots are designed to catch surface run-off using a system of flumes (gutters) and tanks. There also is a weather station on site to measure precipitation amounts and intensities. Together this allows us to determine surface water and soil losses, nutrients in each, and water infiltration into the soil for plant use as influenced by biomass cropping system (switchgrass, Miscanthus, poplar, sorghum versus corn-the control cropping system. We can also estimate water productivity (yield per unit of water). Modeling will be used to predict these attributes at other locations based on rainfall, climate, soil, biomass crop, etc.

A full description of the field tour activities is provided in Exhibit 6. CenUSA Annual Meeting Field Tour Agenda.

A new meeting feature was a poster session and reception featuring the nine CenUSA interns and additional graduate students supported by the project. The session was well attended and students, collaborators and Advisory Board members were in agreement that the session should be held in all subsequent annual meetings. Participants completed a meeting evaluation that will be used in planning the 2013 annual meeting (See Exhibit 7. 2013 Annual Meeting Evaluation).

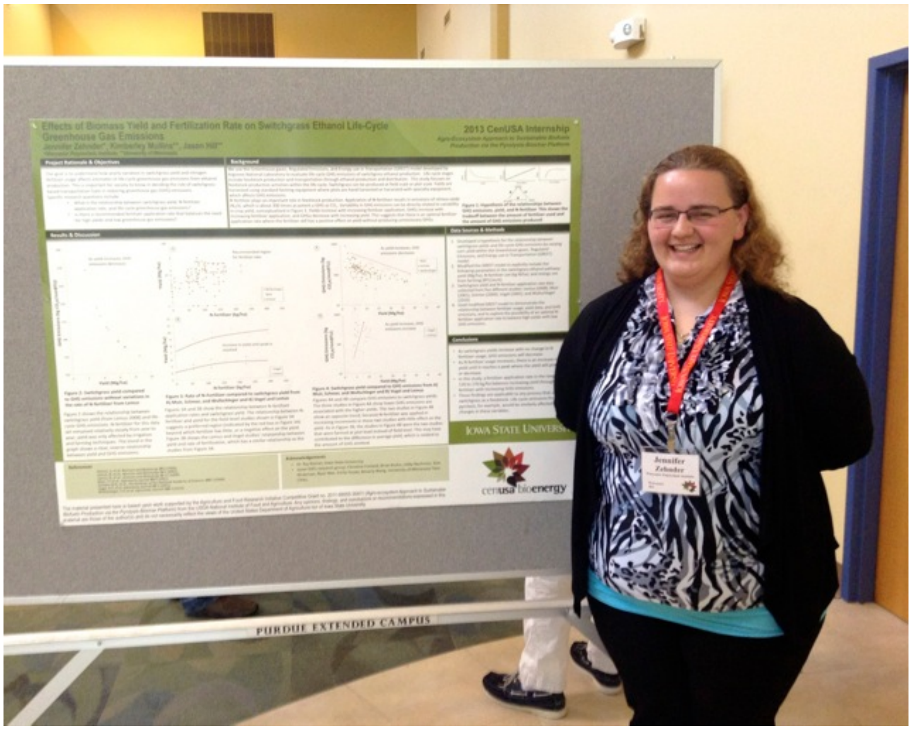

Photo 2. CenUSA intern Jennifer Zehnder (Worcester Polytechnic Institute.) shows off the fruits of a summer full of work. Jennifer worked with Jason Hill at UMN.

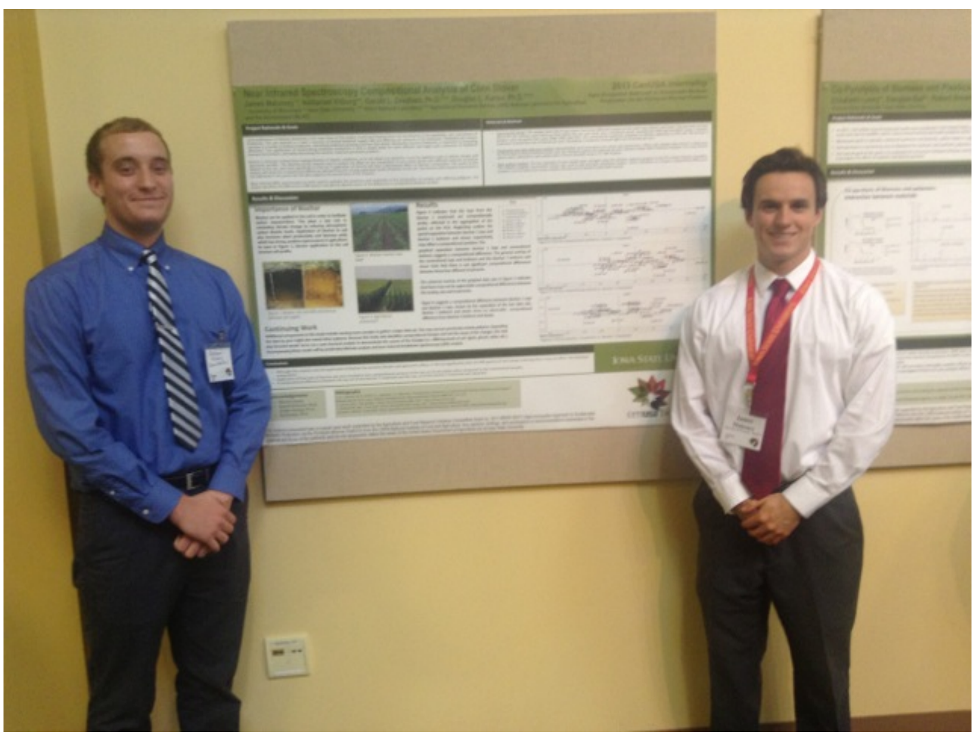

Photo 3. Interns Nathanael Kilburg (ISU) (Left) and James Mahoney(Univ. of Wisconsin, Madison (Right) spent the summer working with Doug Karlen & Gary Gresham at the Idaho National Laboratory.

- ✓ **2014 Annual Meeting.** The 2014 Annual will be held in Minneapolis and will be hosted by the University of Minnesota with personnel from both the *System Performance, Metrics, Data Collection, Modeling, Analysis and Tools* and the *Extension and Outreach* objectives.

- ✓ **Executive Team Meetings.** The objective leaders continue to meet monthly with Ken Moore, Anne Kinzel and Val Evans via online meetings held in CenUSA's dedicated Adobe Connect meeting room. The virtual meeting room allows for documents to be viewed by all participants, enhancing communications and dialogue between participants. Tom Binder, the Advisory Board chair also attends these meetings, to ensure there an Advisory Board presence during these important project gatherings.

- ✓ **Graduate Research Seminars.** Starting in February 2013, we began holding the *CenUSA Research Seminar Series* to coincide with the monthly Co-Project director meeting. The Research Seminars are held in the CenUSA Adobe Connect meeting room immediately following the monthly executive team meeting.

  Each seminar focuses on the work of a CenUSA objective. The presentations feature both CenUSA Co-project directors and CenUSA graduate students, and include a question and answer period.

  - **Feedstock Development Objective Research Seminar (Feb. 22, 2013)**
    - *Twenty Years of Switchgrass Improvement to Create a Dedicated Bioenergy Crop* (Michael Casler and Ken Vogel)
    - *Genomic Selection to Improve Biomass Yield of Switchgrass* (Emily Rude and Guillaume Ramstein)
  - **Sustainable Feedstock Production Systems Objective Research Seminar (Mar. 29, 2013)**
    - *Biochar Mediated Changes in Soil Quality, Nutrient Uptake, and Maize Yield in Two Ongoing Field Trials* (Natalia Rogovska)
  - **Feedstock Logistics Objective Research Seminar (Apr. 25, 2013)**
    - *Perennial Grass Feedstock Logistics* (Kevin Shinners and Stuart Birrell)

  The series will resume in September 2013 and continue throughout 2014.

  - **System Performance Objective Research Seminar (Sep. 27, 2013)**
    - *System Performance Metrics, Data Collection, Modeling, Analysis and Tools* (Jason Hill)

- ✓ **Objective and Team Meetings.** All nine CenUSA Objectives participate in scheduled meetings using the CenUSA Adobe Connect meeting room or in face-to-face meetings.

- ✓ **Special Events**

  - **American Society of Agronomy, Crop Science Society of America and Soil Science Society of America International Annual Meeting, October 21-24, 2012, Cincinnati, Ohio**

    CenUSA Project Director Ken Moore, CenUSA Co-Project Directors Stuart Birrell, Robert C. Brown, Michael Casler, Dermot J. Hayes, Mark Hanna, Jason Hill, Cathy Kling, Keri Jacobs, David Laird, Robert Mitchell, Patrick Murphy, Raj Raman, Kevin Shinners, Kenneth Vogel and Jeffrey Volenec and CenUSA COO Anne Kinzel attended the *Sustainable Production and Distribution of Bioenergy for the Central USA: An Agro-Ecosystem Approach to Sustainable Biofuels Production Via the Pyrolysis-Biochar Platform* meeting held in conjunction with the ASA, CSSA and SSSA International Annual Meeting in Cincinnati, Ohio. Ken Moore provided an update on the CenUSA project.

  - **Workshop: Roadmap to Commercialize Thermochemical Biofuels and Bio-Products Processing in the Midwest, December 11-12, 2012 Iowa State University**

    The workshop *Roadmap to Commercialize Thermochemical Biofuels and Bio-Processing in the Midwest* was held December 11-12, 2012 at Iowa State University in Ames, Iowa. CenUSA, the ISU Bioeconomy Institute, the USDA Central-East Regional Biomass Research Center, Iowa NSF EPSCoR, and the Iowa Energy Center sponsored the workshop (See Exhibit 8. Workshop Agenda and Attendee List).[2]

    The workshop focused on optimal feedstocks and commercial pathways and had three primary goals:

    - Fostering relationships between CenUSA researchers, other interested faculty, Midwest agricultural producer groups, and the thermochemical processing industry.

    - Identifying optimal biomass feedstock characteristics for thermochemical processing of biomass.

    - Identifying commercial pathways for thermal chemical processing of herbaceous biomass to in the Midwest region.

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[2] Iowa EPSCoR is funded by grant number EPS-1101284 from the National Science Foundation. Information is available at http://iowaepscor.org/

Photo 4. CenUSA CoProject Director Stuart Birrell explains the finer points of feedstock logistics at the Roadmap Workshop (December 2013).

Beyond these broad goals the workshop agenda focused on the following objectives:

- Identifying commercial pathways for thermochemical technologies in the Midwest.

- Providing a forum for representatives leading companies in commercialization of thermochemical processing of biomass to share their technologies, goals, desired type of feedstock, and amount of biomass needed for commercial operation.

- Providing a panel of experts on plant breeding and agronomy to describe how different agricultural approaches can be used to optimize the yield of biomass feedstocks while minimizing undesirable components such as ash, nitrogen, and moisture.

- Having experts from Iowa State University and the USDA discuss non-fuel products such as heating oil, biochar, and bioasphalt that can be made by thermochemically processing biomass.

- Bringing together representatives from agricultural producer groups to describe to industry representatives and academic researchers how they brought past bioenergy projects to fruition and their criteria for new projects.

Tables 2 and 3 show the technologies and attendees represented at the workshop.

Table 2. CenUSA Workshop: Technologies Represented	
ADM	Acetic Acid Pulping
BP	Gasification
Chevron	Solvent Liquefaction
GTI	Pyrolysis
KiOR	Catalytic Pyrolysis
ICM	Gasification
P66	Pyrolysis
Renmatix	Solvent Liquefaction
UOP	Pyrolysis
Virent	APR/ Catalytic

Table 3. CenUSA Workshop: Industry Representatives	
Rod Backhaus	Producer - Tall Corn Ethanol
Manuk Colakyan	Renmatix
Bill Couser	Lincolnway Energy
Bob Freeman	Frontier Labs
Paula Hassett-Flowers	UOP
Andrew Held	Virent
Mark Hughes	P66
Byron Johnson	P66
Dmitry Kazachkin	Renmatix
Paul Keeney	Producer - KAAPA
Mark Laurenzo	Producer - IDEA
Frank Lipiecki	Renmatix
Terry Marker	GTI
Peter Metelski	BP
Brad Petersburg	Producer - Ag Ventures Alliance
Magdalena Ramirez	KiOR
Howard Roe	Producer - Tall Corn Ethanol
Bob Rozmiarek	Virent
Rusty Schmidt	Producer - Ag Ventures Alliance

Harry Stine	Producer - Stine Seeds
Jeff Stroburg	Producer - West Central Coop
Rod Williamson	Iowa Corn Growers
Michelle Young	Chevron

- **Workshop Outcomes.** The workshop script yielded lively interaction between the participants that was well captured in the *Roadmap to Commercialize Report* (See Exhibit 9. Roadmap to Commercialization Report), and in the Workshop Evaluation Report (See Exhibit 10. Workshop Evaluation Report). The responses in the *Roadmap to Commercialization Report* demonstrated the participants were very engaged with each other and willing to offer many thoughtful suggestions and observations.

  The workshop's key takeaway points included:

  - The thermochemical industry is moving towards commercialization and is robust enough to handle diverse feedstocks.
  - Collecting and processing cellulosic material can improve agronomic practices.
  - Stover collection is needed on some fields.
  - Biochar addition improves soil and yields.
  - The fact that a vast array of companies and individuals are working towards the same goal creates an atmosphere for things to get done.
  - There is farmer cooperative interest in partnering with and supplying the thermochemical industry.

- **Key Recommendations.** Participants also made the following key recommendations:

  - Create a multi-industry consortium, develop a shared vision, promote R&D, etc. to widely engage geographically diverse supply chain and stakeholders groups.
  - Promote education and communication between producers and industry so that risks are understood and options can be developed to address risk.
  - Look at vertical integration that identifies the specifics of the processes that need improvement.

- **Key Post-Workshop Follow-Up Actions**. As we had hoped, the workshop helped create some new working relationships between the CenUSA research team, agricultural producer industry participants. These enhanced relationships yielded these promising results:

- **Environmental Interest Group Workshop**. The workshop provided the impetus for CenUSA hosting a workshop in Minnesota with the Mississippi Watershed Hypoxia Basis in Task Force scheduled for September 22-24, 2013. CenUSA CoPd Jason Hill (System Performance Metrics, Data Collection, Modeling Analysis, and Tools) is leading this effort. Hill will also apply for a USDA-NIFA conference grant to support the event. This meeting was a direct outcome from discussions that took place at the workshop and the CenUSA Bioenergy mid –year meeting that took place immediately following the Commercialization Workshop (see below).

- **Data and Material Sharing**. Based on the participants' comments and observations from the CenUSA research team, we prepared a brief survey to share with industry participants (See Table 4). The survey was sent out the second week of January 2013.[3]

  Survey results showed participants were interested in advancing the performance of herbaceous biomass in thermochemical processing by participating in one or both of the following activities:

  - Testing Midwest-produced herbaceous biomass in their system; and

  - Sharing data from prior tests with herbaceous biomass in their particular process.

Table 4. Post-Workshop Industry Survey
1. Would you be interested in testing herbaceous biomass materials produced in the Midwest in your bench or pilot processing equipment if the material is provided to you at no cost and is well characterized? * If you answer "no," please skip to question 6.
2.a. What quantity switchgrass feedstock would you need in order to conduct the tests? (In Tons)
2b. What quantity Indian Grass feedstock would you need in order to conduct the tests? (In Tons)
2c. What quantity Big Blue Stem feedstock would you need in order to conduct the tests? (In Tons)
2d. What quantity corn stover (single pass, clean) feedstock would you need in order to conduct the tests? (In Tons)
3. Please specify the acceptable particle size range

[3] https://docs.google.com/spreadsheet/viewform?formkey=dGJuQ3RHZjhFOFFFVmh4SkFJRkZfX1E6MQ#gid=0

4. When would you like to receive the materials?
5. [Demographic Questions]
6. Has your company already conducted tests with herbaceous biomass in thermochemical processes? (If you answer "yes," please answer question 7 as well.)
7. Would you be willing to share information about how herbaceous biomass performed in your process and your wish list for characteristics to optimize performance in your system(s)?

Table 5. Initial Industry Survey Responses	
ADM	ASAP: CenUSA to provide small bales or 1 kg of each of the types of biomass. By 8/1/13 provide big bales of each of the types of biomass.
KiOR	By 4/30/13: CenUSA to provide Switchgrass, Indian Grass, and Big Blue Stem samples.
Catchlight	Has already conducted tests with herbaceous biomass and will provide CenUSA with their existing data.

- **Workshop Evaluation**. The evaluation findings were overwhelmingly positive and can be found in CenUSA's Year 2 Q-2 Report (February 2013) at https://www.cenusa.iastate.edu/PublicFile/_GetPublicFile?publicFileId=65

- **Delivering Feedstock to Industry**. At the workshop we made agreements with industry partners to provide them with feedstock in exchange for a commitment to sharing data from their conversion process. The arrangements for the types of feedstock desired were completed and we have been delivering the feedstocks and will continue to do so into early in the fourth quarter Project Year 2.

- **CenUSA Planning & Collaboration Meeting – December 12-13, 2012**. **Immediately** following the Roadmap Workshop the CenUSA executive team met in Ames to discuss commercialization and transdisciplinary opportunities for the CenUSA project. The meeting provided CenUSA co-project directors with the opportunity to engage in additional research planning and share information from fall 2012 harvest activities.

- **Louisiana State University SUBI (CAP) Annual Meeting January 23-25, 2013.** CenUSA COO Anne Kinzel participated in the SUBI (CAP) annual meeting.

- **Environmental Interest Group Workshop**. CenUSA will host a workshop in Minneapolis, Minnesota for environmental interest groups. The meeting is tentatively scheduled for the 23-25th of September 2013. CenUSA CoPd Jason Hill (System Performance Metrics, Data Collection, Modeling Analysis, and Tools) and Jill Euken (CoPd, Extension and Outreach) will lead this effort. The meeting will be jointly held with the *Mississippi River Gulf of Mexico Watershed*

Nutrient Taskforce (http://water.epa.gov/type/watersheds/named/msbasin/index.cfm). Hill and Euken have applied for a USDA-NIFA conference grant to support the event. This meeting was a direct outcome from discussions that took place at the CenUSA Bioenergy mid –year meeting that took place immediately following the Commercialization Workshop.

Figure 1. Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops Flyer

✓ **Communication Platforms.** CenUSA continues to focus on internal and external communication needs. We continue to operate the CenUSA Bioenergy website (www.cenusa.iastate.edu) to serve both the needs of project collaborators and the interested public at-large. The website is divided into a private and password protected internal space and a publicly accessible external space. We have two primary website goals:

- Serve the needs of the CenUSA research team by providing a repository of information that can be easily shared across project objectives, and
- Allow the interested public maximum access to this taxpayer funded research effort.

We use the website to broadly disseminate reports, learning modules, articles, and webinars. We also use the site to promote CenUSA events and activities such as educational meetings, webinars, media events, eXtension bioenergy learning modules, field days, and networking opportunities.

CenUSA also maintains a Twitter account (@CenUSABioenergy). We use this platform to quickly distribute information regarding CenUSA events, publications, and relevant developments in the fields of biofuels and bioenergy. As of the end of Year 2 we have 191 Twitter followers.

CenUSA uses three separate websites to distribute project webinars: a YouTube Channel (http://www.youtube.com/user/CenusaBioenergy), a Vimeo Channel (VIMEO) (http://www.vimeo.com/user/CenusaBioenergy), and the CenUSA website. While not originally planning on having this many video sites, we have learned that certain employers place restrictions on the types of video sites that employees can access. We have been advised that this combination of sites will make our materials broadly accessible.

We also share project photos are shared via a Flickr.com site (CenUSA Bioenergy).

- **Financial Matters.** As we anticipate receiving the full complement of our third year funding, we will begin issuing subcontract amendments in early October. This estimate is based on past USDA performance.

- **Annual Report Organization**

  Previously, CenUSA submitted quarterly reports for the first three quarters of 2013. Each of these reports is available to the public via the CenUSA website (See http://www.cenusa.iastate.edu/ResourceLibraryItems). This annual report primarily covers events that have taken place during the period May 1 to July 31, 2013. Where needed for clarity of reporting we will address events that have taken place throughout 2013. We have provided an executive summary for the project as a whole as well as executive summary for each of the nine CenUSA objectives (See Figure 2. CenUSA Bioenergy Organization Chart) on the following page.

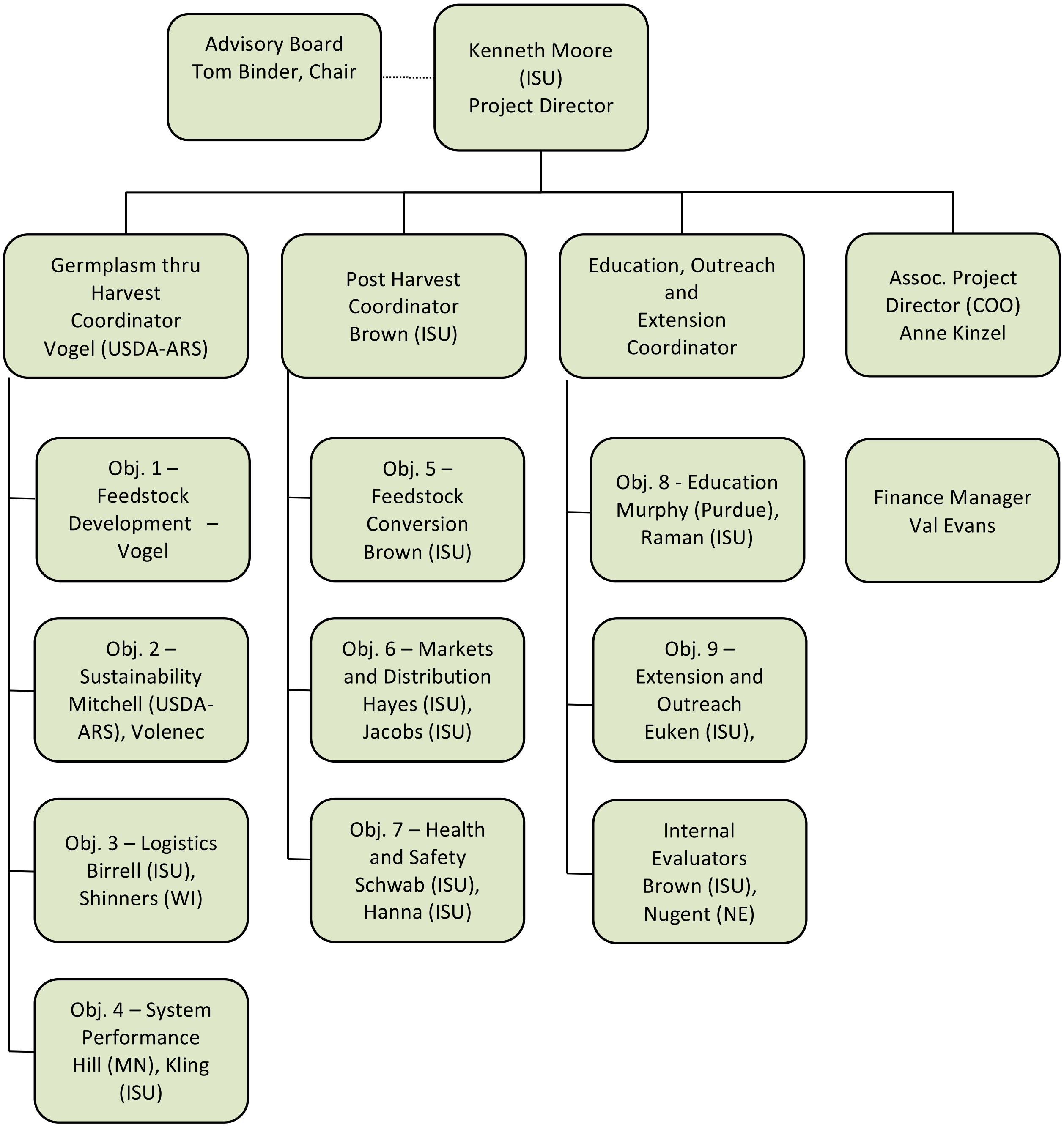


Figure 2. CenUSA Bioenergy Organization Chart

Germplasm to Harvest Research Group

Ken Vogel, Supervisory Research Geneticist at the USDA Agricultural Research Service (Northern Plains) leads the Germplasm to Harvest research group.

The **Germplasm to Harvest** group focuses on four project objectives:

- Feedstock Development
- Sustainable Feedstock Productions Systems
- Feedstock Logistics
- System Performance Metrics, Data Collection, Modeling, Analysis and Tools.

Objective 1. Feedstock Development

The Feedstock Development objective focuses on developing perennial grass cultivars and hybrids that can be used on marginal cropland in the Central United States for the production of biomass for energy. In 2013, the research team has concentrated on the establishment of new switchgrass breeding and evaluation trials.

1. Planned Activities (May 1, 2013 – July 20, 2013)

- **Breeding and Genetics – ARS-Lincoln, Nebraska (Ken Vogel)**

  ✓ Establish two switchgrass and three big bluestem polycross nurseries.

  ✓ Establish three new field selection and genetic evaluation nurseries.

  ✓ Complete all late spring and summer field cultural practice work.

  ✓ Complete stand counts and winter survival ratings on all nurseries.

  ✓ Collect data on flowering time and plant height of plants in specific nurseries.

  ✓ Complete statistical analyses of *Biomass Mineral Analysis Study 1*.

  ✓ Complete initial summary of data from first set of comprehensive composition and pyrolysis analyses for set of switchgrass families differing in lignin and mineral concentration.

  ✓ Develop additional sets of switchgrass, big bluestem, and indiangrass samples for composition and NIRS analyses.

- ✓ Complete NIRS purchase and set up.

- **Breeding & Genetics – ARS-Madison, Wisconsin (Mike Casler)**

  - ✓ Maintenance of switchgrass and big bluestem nurseries at two locations.
  - ✓ Maintenance and management of CenUSA cultivar trials at three locations, including oversight and coordination of 10 additional locations.
  - ✓ Collect data on flowering time and plant height of all plants in all nurseries.

- **Compositional Analyses – ARS-Peoria, Illinois (Bruce Dien)**

  - ✓ Analyze first set of switchgrass biomass samples (52 samples) and begin development of ferulic acid measurement assay.

- **Pyrolysis – ARS- Wyndmoor, Pennsylvania (Akwesi Boateng)**

  - ✓ Continue writing, with Gautam Sarath, a manuscript on relationships between germplasm properties and product yields.
  - ✓ Perform py-GC/MS experiments on larger set of samples of various switchgrass germplasms. Using statistical analysis, identify variations in pyrolysis behavior and products among the larger sample set. Correlate data with compositional data and NIRS spectra of the sample set.

- **Entomology - University Nebraska - Lincoln (Tiffany Heng-Moss)**

  - ✓ Monitor bioenergy grass nurseries for arthropod presence and seasonal abundance.
  - ✓ Evaluate selected switchgrass and other bioenergy grasses for susceptibility/resistance to aphids.

- **Plant Pathology – University Nebraska - Lincoln (Gary Yuen)**

  - ✓ Re-evaluate switchgrass selection nurseries (PV1103, PV1104 and PV910-2102) for the second growing season for virus and fungal leaf disease severity. These nurseries were initially evaluated in 2012.
  - ✓ Resample the switchgrass genetic and yield nurseries two viruses, Panicum mosaic virus (PMV) and satellite PVM (SPMV).
  - ✓ Monitor additional perennial grass and research trials for diseases including CenUSA yield and systems analyses trials at the University of Nebraska's Agricultural Research and Demonstration Center (ARDC) near Mead, Nebraska.

2. Actual Accomplishments (May 1, 2013 – July 20, 2013)

- **Significant Accomplishments Summary**. Mineral composition of biomass can have an effect on the conversion of biomass to liquid fuels by pyrolysis because of the high temperatures used in pyrolysis. Several laboratory methods can be used to measure mineral concentration of biomass. A study was completed which compared the precision and accuracy of public and private laboratories that analyze plant biomass and grains for mineral element composition on a fee basis using different laboratory procedures. Samples sent to laboratories included five switchgrass standard samples known to differ in total ash and mineral concentration and a purchased National Institute of Standards and Technology (NIST) certified standard. The samples were all coded. Each laboratory received three replicates of the switchgrass standards and two replicates of the NIST standard. There were significant differences among laboratories, for both accuracy as measured by deviation from the NIST standard, and precision as measured by the relative standard deviation of the switchgrass samples. The results indicate that there is a wide variation among laboratories for accuracy and precision of mineral element composition analyses of biomass. The laboratory that had the best accuracy also had the best precision. The ICP-OES-HB procedure used by the best laboratory was also used by some of the other laboratories that had much lower accuracy and precision. Results indicate that within laboratory operating and quality control procedures are likely responsible for analytical quality differences among the laboratories. For mineral composition analyses of biomass, the use of standards and laboratory controls will be needed to obtain reliable data.

- **Specific Accomplishments**

  ✓ **Breeding and Genetics – ARS-Lincoln, Nebraska (Ken Vogel)**
  All planned activities completed and milestones were met. Specific accomplishments are listed below.

  - All planned polycross nurseries were established. All planned new field evaluation and selection nurseries were established including establishment of a field evaluation nursery of all full sib families produced in the greenhouse-crossing program during the winter of 2012-2013.

  - All summer plot management completed as scheduled. Stand counts and winter survival notes obtained on all nurseries. Data collected on flowering date for switchgrass nurseries.

  - Data from first set on biomass samples is being analyzed for composition and pyrolysis products were collected.

  - Completed statistical analyses of *Biomass Mineral Analysis Study 1*. See results summary, above.

- Developed additional sets of switchgrass, big bluestem, and indiangrass samples for composition and NIRS analyses.

- New NIRS was ordered. The unit is expected to be delivered in September 2013. Set up and calibration will be completed after delivery.

✓ **Laboratory Comparisons of Mineral Element Composition of Switchgrass Biomass (*Biomass Mineral Analysis Study 1*) – ARS-Lincoln, Nebraska (Ken Vogel)**

Mineral composition of biomass can have an effect on the conversion of biomass to liquid fuels by pyrolysis because of the high temperatures used in pyrolysis. Several laboratory methods can be used to measure mineral concentration of biomass. The purpose of this study was to compare the precision and accuracy of public and private laboratories that analyze plant biomass and grains for mineral element composition on a fee basis using different laboratory procedures. The elemental composition of biomass can be determined by inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma optical emission spectrometry (ICP-OESP. Two digestion procedures can be used to prepare samples for the ICP-OES procedure, hot block digestion (HB) and microwave digestion (MW). Samples sent to laboratories included five switchgrass standard samples known to differ in total ash and mineral concentration and a purchased National Institute of Standards and Technology (NIST) certified standard. The samples were all coded. Each laboratory received three replicates of the switchgrass standards and two replicates of the NIST standard. The NIST standard was the tomato leaf standard, SM 1573, which was used as the control. There were significant differences among laboratories for both accuracy, as measured by deviation from the NIST standard, and precision as measured by the relative standard deviation of the switchgrass samples (See Tables 2 and 3).

The results clearly indicate there is a wide variation among both university service laboratories and commercial laboratories in accuracy and precision of mineral element composition analyses of biomass. The laboratory (Lab E) that had the best accuracy also had the best precision. Lab E used the ICP-OES-HB procedure. Because other laboratories that used similar equipment had much lower accuracy and precision, these results indicate that within laboratory operating and analytical quality control procedures differentiate the quality of the laboratory results among the laboratories tested in this study. For mineral composition analyses of biomass, the use of standards and laboratory controls will be needed to obtain reliable data.

Table 6. A comparison of laboratory accuracy for measuring mineral element composition of plant biomass using a NIST standard SRM 1573a – tomato leaves in a blind analyses with r=2. • Mean with an * indicates the it is significantly different from the NIST certified value as tested by Dunnett's t test at P < 0.05.								
Method†	Lab	Ca	P	Mg‡	K	Na	Fe	Zn
		……… …	……… …	……… …	mg kg^{-1}	……… …	………	……… …
NIST	NIST	50500	2160	12000	27000	136	368	30.90
ICP-MS	A	41324*	2766	10132*	19710*	243*	108*	10.00
ICP-OES	B	59977*	2443	11920	26266	388*	371	32.80
ICP-OES-HB	C	43915*	1932	9295*	24678*	114	298*	27.30
ICP-OES-HB	D	54195*	2450	11265	29250*		308*	29.00
ICP-OES-HB	E	48500	2200	10600*	27900	90*	315*	31.50
ICP-OES-HB	F	58121*	2495	12388	17799*	154	370	36.40
ICP-OES-MW	G	57498*	2269	11912	11687*	131	354	30.80
Mean		51837	2351	11135	22772	183	308	28.40
CV		1.18	15.12	2.62	1.81	3.48	3.02	24.60
F test		250**	0.98	26.4**	419**	525**	170**	2.59

† ICP-MS = ICP mass spectrometry, ICP-OES = ICP Optical emission spectrometry,
ICP-OES-HP = ICP OES hot block digestion , ICP-OES-MW = ICP-OES microwave digestion.
** F test indicates laboratory results for the NIST sample analyses are significantly different at the 0.01 level.

Table 7. Mean and standard deviation (SD) of mineral element composition of five switchgrass standard samples as determined by different laboratories. Each laboratory in a blind, replicated trial analyzed three subsamples of each standard.						
Method†	Lab	Ca	P	Mg	K	Na
		…………	…………	mg kg^{-1}	………..	…………
ICP-MS	A	2306 (444)	1344 (792)	867 (193)	11847 (3849)	146 (52.9)
ICP-OES	B	1531 (361)	1151 (788)	872 (175)	6472 (3195)	256 (5.87)
ICP-OES-HB	C	2357 (254)	1006 (585)	1072 (172)	8971 (3560)	17.3 (7.82)
ICP-OES-HB	D	3066 (293)	1267 (660)	1491 (264)	10327 (4051)	
ICP-OES-HB	E	2587 (280)	1140 (624)	1253 (168)	10060 (3811)	32.7 (14.9)
ICP-OES-HB	F	3605 (311)	1247 (669)	1349 (176)	6763 (2161)	22.9 (9.86)
ICP-OES-MW	G	2829 (269)	1166 (694)	1287	5187	18.8 (8.12)

				(193)	(1595)	
Mean		2611	1189	1170	8518	82.3
CV		8.99	14.4	9.62	9.53	26.3
SE mean		135.26	98.84	65.32	469.36	12.49
MSE		234	171	113	812	21.6
F test		116**	6.10**	68.4**	134**	311**
*, ** F test indicates laboratory means are significantly different at the 0.05 and 0.01 level, respectively.						

✓ **Breeding and Genetics – ARS-Madison, Wisconsin (Mike Casler)**

All planned activities completed and milestones have been met. Specific accomplishments are listed below.

- We collected heading date and plant height data on SWAG1, SWAG2, and SWAG3 genomic selection nurseries, and on two big bluestem nurseries planted in 2011 and 2012.

- We conducted routine maintenance of all new nurseries planted in 2013.

✓ **Compositional Analyses – ARS-Peoria, Illinois (Bruce Dien)**

All planned activities completed and milestones were met. Specific accomplishments are listed below.

- Ken Vogel supplied 52 switchgrass samples (CenUSA Sample Set 1). Samples were from lowland switchgrass half-sib families harvested after a killing frost that differed significantly for ash and acid detergent lignin. Data will be used to obtain an estimate of the effect of genetic differences in feedstock composition on pyrolysis yields. Samples were analyzed in duplicate for soluble, storage, and structural carbohydrates as well as lignin; Table 3 summarizes sample statistics for the set. The analysis errors were generally below 5 percent for all except soluble sugars, uronic acid, and soluble lignin; however, all of these components are minor constituents. The total mass sum of everything measured accounted for 709.3 – 934.8 g/kg of the total biomass. The missing components include protein, lipids, and total ash. These are in the process of being measured. The theoretical ethanol was calculated from the carbohydrate data. A wide distribution of values was observed (294 – 403 g/kg).

- A reverse phase HPLC was set up to measure ferulic acid. One of the reference switchgrass samples (MPV2) was extracted with 2 N NaOH under mild conditions and analyzed for ferulic and p-coumaric acids using the HPLC system

(See Figure 1). The extract was analyzed at two wavelengths (320 and 254 nm). The 254 nm allowed for detection of ferulic and p-courmaric but 320 nm was more sensitive for ferulic acid detection.

Table 8. Statistics for 52 switchgrass samples from a genetic study in which switchgrass lowland families differed significantly in total ash and acid detergent lignin.				
Component	Mean	CV[2]	Low	High
	g/kg	%	g/kg	g/kg
Soluble sugars[1]	5.35	9.26	0.08	21.1
Starch	31.0	2.21	5.12	50.5
Structural Carbohydrates				
arabinose	23.8	3.01	5.12	50.5
galactose	10.2	3.94	3.01	19.36
glucose	306.8	2.22	258.2	391.1
xylose	211.6	2.24	181.5	251.1
uronic acid	18.7	6.00	10.8	27.1
Klason lignin	153.9	2.16	138.1	187.2
Soluble lignin	13.1	6.69	10.2	24.5
Sum	774.4		709.3	934.8
Theoretical Ethanol	335.1		294.2	402.8
[1] Soluble sugars ucose, fructose, and sucrose, [2]CV = standard deviation / mean				

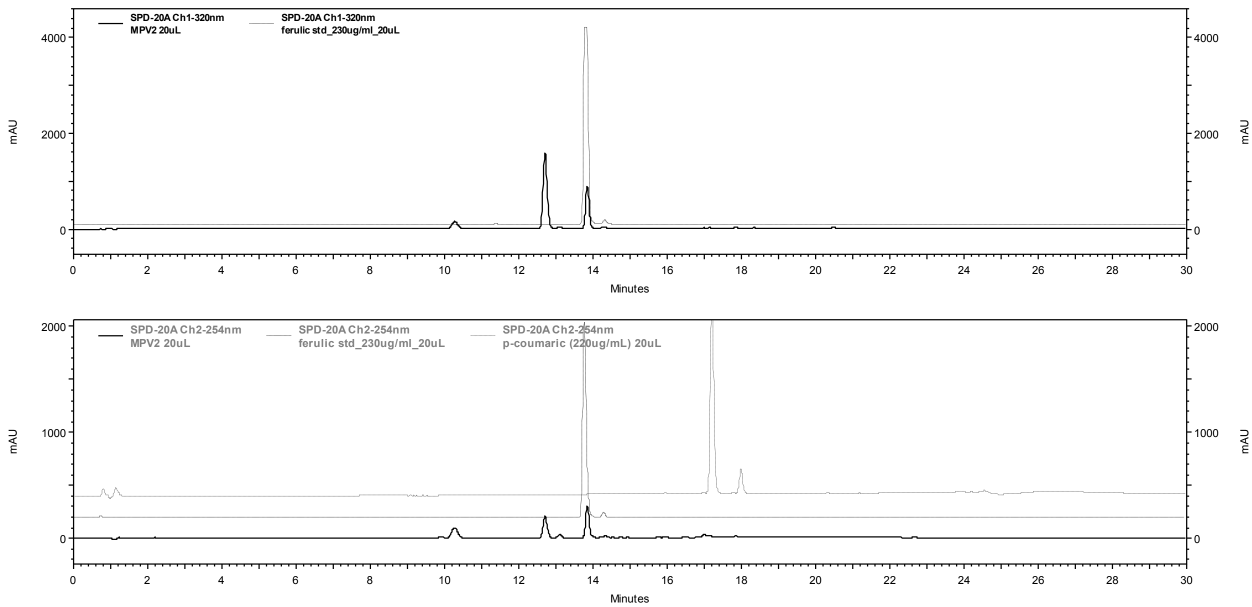


Figure 3. Switchgrass reference sample extracted with 2 N NaOH at room temperature and analyzed for ferulic acid.

✓ **Pyrolysis – ARS- Wyndmoor, Illinois (Akwesi Boateng)**

- The manuscript has been partially written, but not completed; a draft results section is complete.
- We completed the ultimate analysis of all 94 samples received, including Sample Nos. 80113-85013, Sample Nos. 113, 413, 713, and 1013, and the 40 STICH samples (See Table 8. Ultimate analysis of switchgrass samples: Average +/- Standard Deviation (Standards, CenUSA sample sets 1 and 2).
- Completed py-GC/MS analysis of first 50 switchgrass samples (CenUSA Sample Set 1; See Table 5. Table 9. 0r 2 – Py-GS/MS Results: Samples 80113-80513)
- We will continue to analyze data.

Table 9. Ultimate analysis of switchgrass samples: Average +/- Standard Deviation

Sample Group		80113-85013	113-1013	STICH Samples
% water		6.19 +/- 0.22	2.47 +/- 0.85	6.58 +/- 0.43
% ash		4.47 +/- 0.49	4.82 +/- 0.17	4.51 +/- 1.27
Dry Ash-Free Basis	% Carbon	49.97 +/- 0.77	48.67 +/- 0.28	48.34 +/- 1.16
	% Hydrogen	5.55 +/- 0.31	5.38 +/- 0.09	5.86 +/- 0.28
	% Nitrogen	0.62 +/- 0.09	0.72 +/- 0.15	0.72 +/- 0.32
	% Oxygen	43.86 +/- 0.94	45.23 +/- 0.36	45.08 +/- 1.57

Table 10. 0r 2 – Py-GS/MS Results: Samples 80113-80513		
Compound/Group of Compounds	**mg compound per g biomass – Average +/- Standard Deviation**	**Statistically significant differences between samples?**
Acetic Acid	32.4 +/- 7.3	No
Acetol	13.7 +/- 2.4	Yes
Levoglucosan	9.7 +/- 4.4	No
Furans	3.8 +/- 1.1	Yes
Guaiacols	2.7 +/- 0.7	No
5-membered rings	3.7 +/- 0.8	Yes
Phenols	1.9 +/- 0.3	No

✓ **Entomology – University of Nebraska, Lincoln (Tiffany Heng-Moss)**

All planned activities completed and milestones were met. Specific accomplishments are listed below.

- A total of 160 pitfall and sticky board traps are being collected every two weeks from May to September 2013 in Nebraska and Wisconsin.
- All sampling data from Year 1 have been summarized.

Table 11. Total number of selected arthropod orders collected from switchgrass nurseries during 2012	
Order	**Total**
Thysanoptera	125,781
Coleoptera	21,342
Hemiptera	5677
Hymenoptera	3550
Diptera	3064
Araneae	654
Lepidoptera	340

- **Sampling Season 2012**

  Over the course of the sampling season, specimens representing 84 families of arthropods were collected spanning twelve orders of insects as well as non-insect groups including arachnids.

- Thysanoptera, Coleoptera, and Hemiptera were the most abundant orders, representing over 95% of the total arthropods collected.

- Orthoptera (grasshoppers) were also collected with sweep samples.

- Potential pests were characterized as those arthropods capable of causing injury to switchgrass.

- Three groups of potential pests were identified in this study:

  - Thrips, aphids, and leafhoppers: remove photosynthate thereby decreasing biomass production and have the potential to transmit a variety of plant diseases.
  - Grasshoppers: potential to remove large amounts of biomass in outbreak situations.

  - Chloropid fly larvae: feed within stems, impacting biomass production and potentially decreasing seed production.

  - A number of beneficial arthropods were also collected: parasitoids and predators (ground beetles, rove beetles, spiders).

✓ **Plant Pathology – University of Nebraska, Lincoln (Gary Yuen)**

All planned activities completed and milestones were met. Specific accomplishments are listed below.

- **Sampling and rating of PV1103-70 and PV901-2102 for virus symptoms**. These plots were rated in 2012. The purpose of reexamining these plots in 2013 is to obtain information on the frequency of PMV and PMV+SPMV infection and to obtain a second year of virus severity data to determine how virus incidence and severity change over time.

- **Examination of other plots for diseases, virus diseases in particular**. Virus symptoms were noted in CenUSA yield trials (only switchgrass entries were examined) and in Cave-in-Rock switchgrass planted in grass/corn long-term carbon sequestration trial. No virus symptoms were seen in 'Systems' trial planted with Liberty in 2012. Fungal leaf spot and rust was seen sporadically in all trials, but was not considered to be damaging. Samples were collected from all trials to verify identity of the pathogens.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

- **Breeding and Genetics – ARS-Lincoln, Nebraska (Ken Vogel)**

  ✓ Complete plant and flag leaf height and other phenotype data collection work.

  ✓ Harvest plots, measure biomass yield, and collect quality samples for all nurseries and field trials.

  ✓ Complete and submit manuscript on laboratory biomass mineral analyses study.

  ✓ Complete and submit manuscript on improved crossing method for switchgrass in the greenhouse.

  ✓ Compile composition (Dien), pyrolysis (Boateng), and ARS-Lincoln field and laboratory fiber and field data on CenUSA Set 1 of biomass samples from lowland switchgrass half-sib families that differed significantly in total ash and acid detergent lignin when harvested after a killing frost. Initiate statistical analyses to determine the effects of genetic differences in composition on pyrolysis yields.

- **Breeding and Genetics – ARS-Madison, Wisconsin (Mike Casler)**

  ✓ Maintenance of switchgrass and big bluestem nurseries at two locations.

  ✓ Maintenance and management of CenUSA cultivar trials at three locations, including oversight and coordination of 10 additional locations.

  ✓ Harvest plots, measure biomass yield, and collect quality samples for all nurseries and field trials.

- **Compositional Analyses – ARS-Peoria, Illinois (Bruce Dien)**

  ✓ Analyze new set of switchgrass samples supplied by Mike Casler (40 samples) and complete development of assays for measuring ferulic acid and plant lipids.

- **Pyrolysis – ARS- Wyndmoor, Pennsylvania (Akwesi Boateng)**

  ✓ Continue writing manuscript with Sarath as described in 1a. above.

  ✓ Continue py-GC/MS experiments with remaining samples.

- **Entomology - University of Nebraska, Lincoln (Tiffany Heng-Moss)**

  ✓ Pitfall and sticky board traps will continue to be collected every two weeks from May 2013 until the end of September 2013.

- ✓ Process samples from sampling Year 2 to identify potential pests and beneficial arthropods and characterize their seasonal abundance.

- ✓ Continue to screen selected switchgrass, big bluestem, and indiangrass cultivars and experimental strains for their susceptibility to greenbugs and sugarcane aphids.

- **Plant Pathology – University of Nebraska, Lincoln (Gary Yuen)**

  - ✓ Complete analysis of field samples for presence of PMV, SPMV, and other viruses.

  - ✓ Collect seed from virus symptomatic plants to determine if seed can harbor PMV or PMV+SPMV.

5. Publications, Presentations, and Proposals Submitted

- **Journals**

  Price, D.L. & Casler, M.D. (2013). Inheritance of secondary morphological traits for among-and-within-family selection in upland tetraploid switchgrass. *Crop Sci*. (in review).

  Price, D.L. & Casler, M.D. (2013) Divergent selection for secondary traits in upland tetraploid switchgrass and effects on sward biomass yield. *BioEnergy Res.* (in review).

  Price, D.L. & Casler, M.D. (2013). Predictive relationships between plant morphological traits and biomass yield in switchgrass. Crop Sci. (in press).

- **Abstracts**

  Stewart, C. L., Yuen, G. Y., Vogel, K., Pyle, J. D. & Scholthof, K. B. G. (2013). Panicum mosaic virus—A potential threat to biofuel switchgrass production. Abstract of poster presented at 2013 Annual Meeting of the American Phytopathological Society. http://www.apsnet.org/meetings/Documents/2013_Meeting_Abstracts/aps2013abP461.htm

Objective 2. Sustainable Feedstock Production Systems

The Sustainable Feedstock Production Systems objective focuses on conducting comparative analyses of the productivity potential and the environmental impacts of the most promising perennial grass bioenergy crops and management systems using a network of 14 fields strategically located across the Central United States. The overarching goal is to produce a quantitative assessment of the net energy balance of candidate systems and to optimize perennial feedstock production and ecosystem services on marginally productive cropland while maintaining food production on prime land. In Project Year 2 this team focused on establishment of new test plots.

1. Planned Activities

- Establish Factor Analysis Plots. Where necessary identify location-specific candidate feedstocks and seed plots.
- Secure and analyze soil samples. Fertilize according to soil test recommendations.
- Establish Systems Analysis Plots where appropriate.
- Use best management practices for establishing these biomass species.
- Collect data on existing trials relevant to CenUSA goals and objectives.

2. Actual Accomplishments

- **Iowa State University**

  ✓ **Armstrong System Analysis Plots.** The Iowa System Analysis perennial grass plots were reseeded and weeds controlled as needed. Stand counts for the high diversity, low diversity and switchgrass plots were completed on May 13, 2013. Broadleaf weed pressure was heavy; a likely response to the severe drought in 2012, but warm-season grass establishment is progressing. The control plots were planted to corn. The Decagon 5TE sensors have been collecting soil moisture, temperature, and electrical conductivity data at four depths in each of 32 locations (two per big plot/one per split plot) in the System Analysis Plots. Data loggers are collecting soil moisture, temperature, and electrical conductivity data at 30-minute intervals. Baseline soil analysis is about 75% completed.

  ✓ **Field 70/71.** Evaluating the long-term productivity, soil quality assessment, greenhouse gas (GHG) emissions, and NO_3 leaching following the application of 4.2 and 8.4 tons/acre of biochar. Initial results demonstrate that biochar helps mitigate the negative effects of long-term corn stover removal on loss of soil N mineralization potential. Corn plots were planted and managed in 2013.

  ✓ **Sorenson Long-term Bioenergy Crop Rotation Study**. The purpose is to determine the impact of long-term crop rotations, residue removal and biochar application on sustainability and productivity of bioenergy production systems. Switchgrass, corn, soybeans and triticale were planted in the appropriate phase of each rotation. Biochar was applied on May 13, 2013 on split plots during the first year of the corn in the 6-year rotations, corn and soybeans were planted on May 15, 2013. Preliminary results demonstrate a negative effect of continuous no-till corn with residue removal relative to biochar + tillage + residue harvesting.

✓ **Boyd Biochar Plots.** All plots were successfully planted to corn in 2013. Base stations for monitoring GHG emissions were installed in each plot. Soil moisture retention curves were completed. Results demonstrate that soils in plots receiving the high biochar rate (112 Mg ha^{-1}) have the capacity to retain 60% more plant-available water and reduce soil bulk density compared to the control plots that did not receive biochar applications.

- **University of Illinois Urbana-Champaign**

✓ **Illinois 2012 Factor Analysis Plots.** The perennial grasses in the 2012 plots had inconsistent stands due to heavy grass weed pressure. All 2012 Factor Plots were replanted on May 15, 2013 and pre-emergence herbicides were applied on May 16, 2013. Stands in the 2012 plots have improved and plots may have harvestable yields after killing frost in 2013.

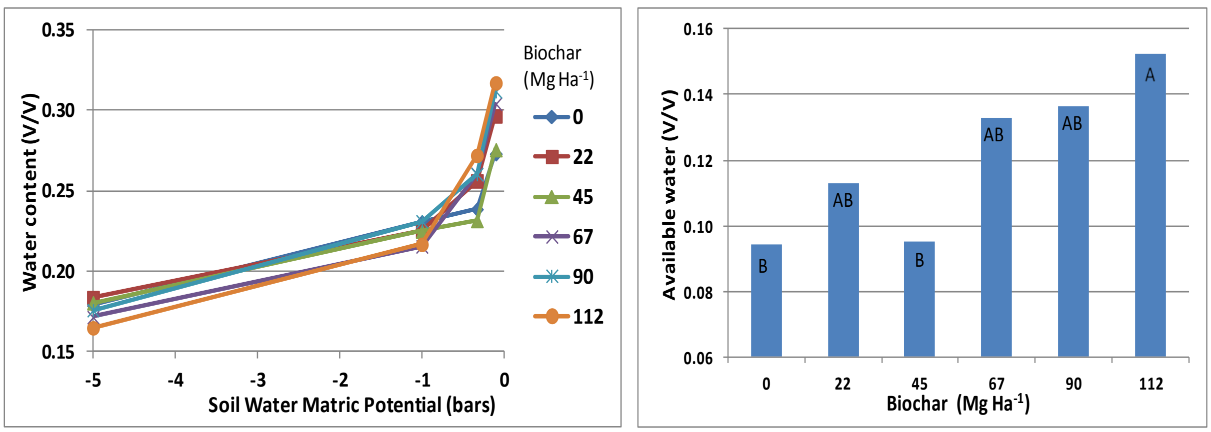


Figure 4. Left, average surface soil moisture retention curves for plots receiving biochar treatments. Right, biochar effects on plant available water. Bars with different letters are significantly different at the 0.05 level.

✓ **Illinois 2013 Factor Analysis Plots.** The plots were planted using a no-till drill on May 15, 2013 and pre-emergence herbicides were applied on May 15, 2013. Miscanthus x giganteus (Mxg) was transplanted on June 4, 2013 and prairie cordgrass monocultures and mixtures were transplanted on July 8, 2013. All plots have excellent stands and weed pressure is being controlled.

✓ **Factor Plot Plans.** Stands in the 2012 and 2013 plots may have harvestable yields after killing frost. Plan to complete soil analysis for the 2013 Factor Analysis Plots.

✓ **Comparison field trials of switchgrass, big bluestem, prairie cordgrass, and Mxg were harvested on November 15, 2012 and biomass yield data has been analyzed (Figure 3).** The plots were transplanted in 45cm and 90cm spacings on wet marginal land in 2010. Plots with 45 cm spacing produced more biomass than 90 cm spacing until 3 years after transplanting. Severe drought stress was observed in prairie cordgrass and Mxg plots during the 2012 growing season and biomass yields for prairie cordgrass and Mxg were lower than switchgrass. Kanlow switchgrass biomass yield was very high (25 Mg/ha) even under extreme drought conditions.

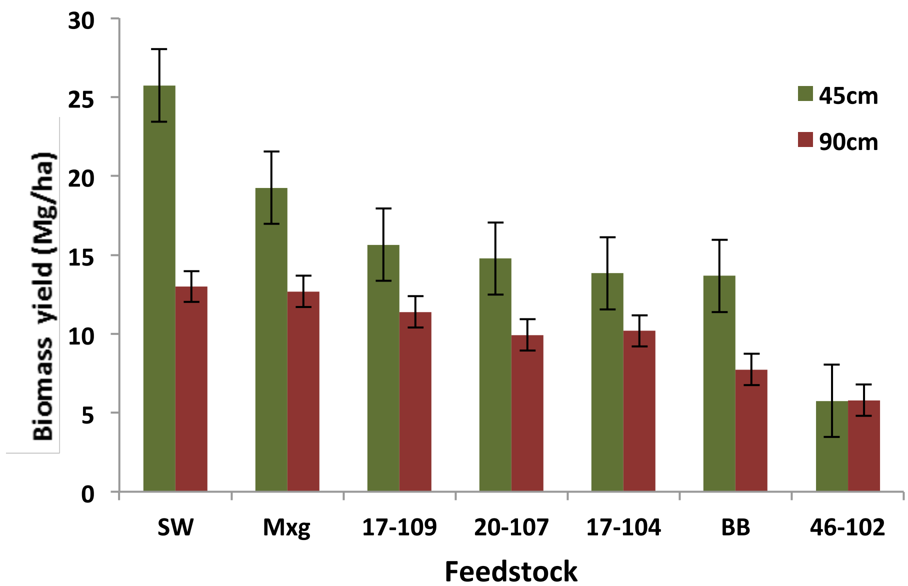


Figure 5. Biomass yield of "Kanlow"switchgrass (SW), Mxg. big bluestem (BB), and four prairie cordgrass populations ('17-109', '20-104', '17-104' and '46-102') at 45cm and 90cm spacing in 2012.

- **University of Minnesota**

  ✓ **Minnesota Factor Analysis Plots**

  - Becker**,** Minnesota**.** The Factor Analysis Plots at Becker, Minnesota were harvested on October 30, 2012 using a Carter harvester. Establishment year data and photos in 2013 appear in Fig. 4 and 5, below. In general, biomass yields were variable, but plots were productive in 2013. Because of the sandy soil texture, nitrogen was applied in a split application on May 23, 2013 and June 25, 2013 at the Becker Factor Plots.

  - **Lamberton, Minnesota.** We planted the 2013 Lamberton Factor Plots on May 16, 2013. Stands for all feedstocks are excellent.

eXtension Article. We collaborated with the extension group to complete an article on switchgrass nutrient management to be published on eXtension.org. The publication is in the final stages of completion.

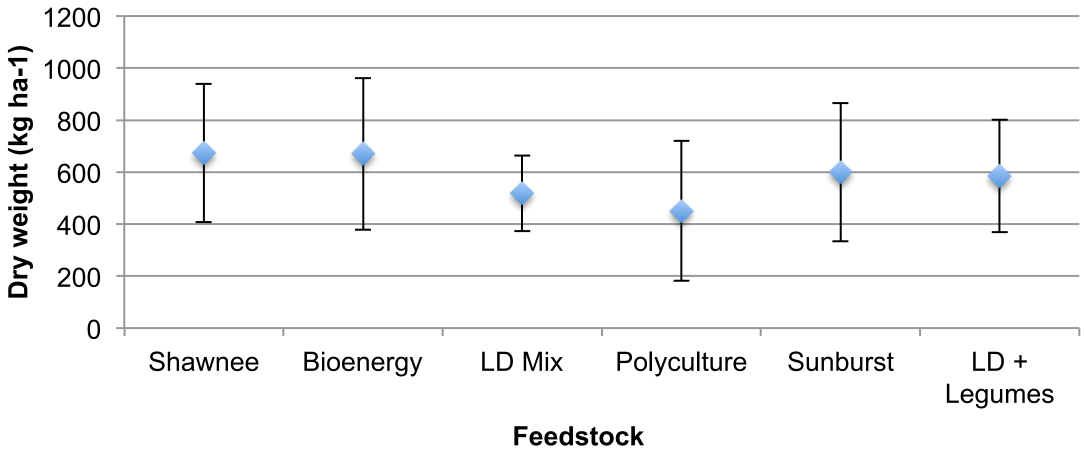


Figure 6. Establishment year yields for perennial grasses planted in 2012 at Becker, Minnesota. Plots were harvested after killing frost on October 30, 2012.

- **Purdue University**

  ✓ **Throckmorton Purdue Agricultural Center**. Baseline GHG emission data from a subset of the Factor Analysis Plots at the Throckmorton Purdue Agricultural Center (TPAC) were acquired. These data were averaged over weekly measurements taken April 22 to May 7, 2013, prior to field operations. Results suggest that perennial biomass production systems may produce slightly more CO_2 and low to moderate levels of CH_4 and NO_2 when compared to maize and biomass sorghum. Addition of 100 kg N/ha to maize and sorghum increases CO_2 and NO_2 emissions over the unfertilized plots.

Photo 5. 'Sunburst' (left) and 'Liberty' (right) switchgrass on 6 June 2013 in the plots seeded in 2012 (pen for scale). Weeds are hoary alyssum and have since been controlled.

Table 12. Emission of greenhouse gasses from candidate biomass system soils fertilized with 0 or 100 kg/ha N fertilizer.				
Biomass System	**Nitrogen rate, kg/ha**	**CO_2, mg/h/m^2**	**CH_4, mg/h/m^2**	**NO_2, mg/h/m^2**
Native prairie	0	225	0	0.009
Switchgrass (Shawnee)	0	340	0	0.014
	100	228	0	0.003
Miscanthus	0	215	0.0005	0.004
	100	282	0	0.008
Sorghum	0	142	0	0.004
	100	182	0.005	0.013
Conventional corn	0	146	0.004	0.011
	100	162	0	0.028

- **TPAC evaluation of Switchgrass and Mxg response to N, P and K fertility.** Switchgrass and Mxg response to N, P and K fertility was evaluated at the TPAC in 2012. Switchgrass was established in 2007 with fertilizer treatments imposed in 2011. Mxg was established in 2009 with fertilizer treatments applied in 2011. None of the fertility regimes increased switchgrass yield in 2011 or 2012. N fertilizer application increased switchgrass tissue N concentration, but tissue P and K were variable. In Mxg, N increased biomass N concentrations but not biomass and P and K increased tissue P and K concentrations but not biomass. Mxg biomass was about 60 percent greater than that of adjacent switchgrass. P concentrations of Mxg were half that of adjacent switchgrass, whereas K concentrations were twice that of adjacent switchgrass.

- **TPAC Factor Plot Mineral Analyses.** Mineral analyses at the TPAC Factor Analysis Plots are being completed. Variable rates of N (0 to 150 kg N/ha/yr) are being applied to Shawnee switchgrass established at a site that had received annually high rates of P and K or left unfertilized (0 or 75 kg/ha P; 0 or 400 kg K/ha) for 8 years of alfalfa production that resulted in large differences in soil P and K levels. Preliminary results of the main effects of the analysis reveal the following:

    - Tissue N increased with the addition of N fertilizer, but declined with high soil test K.

    - High soil test P increased tissue P whereas high soil test K decreased tissue P.

    - Tissue K concentrations increased with the addition of N fertilizer and with high soil test K levels, but declined with high soil test P concentrations.

- Tissue C concentrations were unaffected by N and P, but increased with high soil test K.

- Significant interactions among N, P, and K were identified for some variables, but details are beyond the scope of this interim report and will be made available upon request.

Table 13. Impact of fertilization with nitrogen (N), phosphorus (P), and potassium (K) on tissue mineral and carbon (C) concentrations.

Nutrient	Rate, kg/ha/yr	Tissue N, g/kg	Tissue P, g/kg	Tissue K, g/kg	Tissue C, g/kg
Nitrogen	0	5.17**	0.42	1.92**	469
	50	5.50	0.41	2.01	470
	100	6.17	0.41	2.02	469
	150	6.94	0.41	2.20	470
Phosphorus	0	5.87	0.27**	2.11**	470
	75	6.02	0.56	1.96	469
Potassium	0	6.02*	0.45**	1.70**	468**
	400	5.87	0.38	2.37	471

*, ** nutrient effect on tissue composition significant at the 5 and 1% levels of probability, respectively.

Table 14. Impact of fertilization with nitrogen (N), phosphorus (P), and potassium (K) on tissue composition including concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), total ash, and soluble sugars.

Nutrient	Rate, kg/ha/yr	NDF, g/kg	ADF, g/kg	ADL, g/kg	Ash, g/kg	Sugar, g/kg
Nitrogen	0	717	398	66*	44	13.8
	50	718	397	68	43	13.8
	100	716	403	70	42	13.4
	150	714	394	69	42	14.0
Phosphorus	0	721*	402*	69*	42*	14.0
	75	712	395	67	44	13.5
Potassium	0	712	397	68	44*	13.7
	400	721	399	68	41	13.8

*, ** nutrient effect on tissue composition significant at the 5 and 1% levels of probability, respectively.

- **TPAC Fiber and Sugar Analyses.** Fiber and sugar analyses at the TPAC Factor Analysis Plots are being completed. Variable rates of N (0 to 150 kg N/ha/yr) are being applied to Shawnee switchgrass established at a site that had received annually high rates of P and K or left unfertilized (0 or 75 kg/ha P; 0 or 400 kg K/ha) for 8 years of alfalfa production that resulted in large differences in soil P and K levels.

  Preliminary results of the main effects of the analysis reveal the following:

  - Neutral detergent fiber (NDF) was not affected by N or K, but was reduced in high P soils.
  - Trends in acid detergent fiber (ADF) mirrored those of NDF.
  - Acid detergent lignin (ADL) increased with N fertility, but declined as soil P levels increased.
  - Ash was unaffected by N, but increased as soil P increased and declined as K increased.
  - Biomass soluble sugars averaged approximately 13.8 g/kg and were not affected by soil test P and K, or N fertilizer application.
  - Significant interactions among N, P, and K were identified for other variables, but details are beyond the scope of this interim report. Details will be made available upon request.
- **TPAC Mineral Analyses (Factor Analysis Plots).** Mineral analyses at the TPAC Mxg Factor Analysis Plots are being completed. Variable rates of N (0 to 150 kg N/ha/yr) are being applied to a site that soil tests indicated differed in P and K levels. Plots were blocked and high rates of P and K ("plus" treatment: 75, 400 kg/ha, respectively) were applied or plots were left unfertilized with P and K (minus treatment). The goal is to explore the interaction between P/K fertility and N nutrition of this understudied biomass system.

  Preliminary results of the main effects of the analysis reveal the following:

  - Tissue N increased with the addition of N fertilizer, but there was no effect of P and K on tissue N concentrations.
  - Tissue P concentrations were reduced with N fertilizer application.
  - Tissue K concentrations were unaffected by N fertilizer application, but were increased with application of P and K fertilizers.
  - Tissue C concentrations were unaffected by N and P/K fertility.

- Significant interactions among N and P/K also were identified for some variables, but details of these results are beyond the scope of this interim report. Details will be made available upon request.

Table 15. Impact of fertilization with nitrogen (N) with and without phosphorus (P) with potassium (K) on tissue mineral and carbon (C) concentrations.

Nutrient	Rate, kg/ha/yr	Tissue N, g/kg	Tissue P, g/kg	Tissue K, g/kg	Tissue C, g/kg
Nitrogen	0	4.01**	0.45*	3.56	463
	50	4.47	0.45	4.27	461
	100	4.90	0.34	4.37	462
	150	5.26	0.36	4.28	462
P and K	Minus	4.59	0.38	3.80*	461
	Plus	4.73	0.42	4.43	463

*, ** nutrient effect on tissue composition significant at the 5 and 1% levels of probability, respectively.

- **Fiber and sugar analyses at the TPAC Mxg Factor Analysis Plots.** Fiber and sugar analyses at the TPAC Mxg Factor Analysis Plots are being completed. Variable rates of N (0 to 150 kg N/ha/yr) are being applied to a site that soil tests indicated differed in P and K levels. Plots were blocked and high P and K rates ("plus" treatment: 75, 400 kg/ha, respectively) were applied or plots were left unfertilized with P and K ("minus" treatment). The goal is to explore the interaction between P/K fertility and N nutrition of this understudied biomass system.

Table 16. Impact of fertilization with nitrogen (N) with and without phosphorus (P) with potassium (K) on tissue composition including concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), total ash, and soluble sugars.

Nutrient	Rate, kg/ha/yr	NDF, g/kg	ADF, g/kg	ADL, g/kg	Ash, g/kg	Sugar, g/kg
Nitrogen	0	771	481	81.8	42.8	19.3
	50	771	475	81.9	44.2	18.8
	100	771	480	83.9	44.4	17.8
	150	754	469	81.9	43.9	20.8
P and K	Minus	762	480	83.5	43.4	20.2*
	Plus	771	473	81.3	44.2	18.1

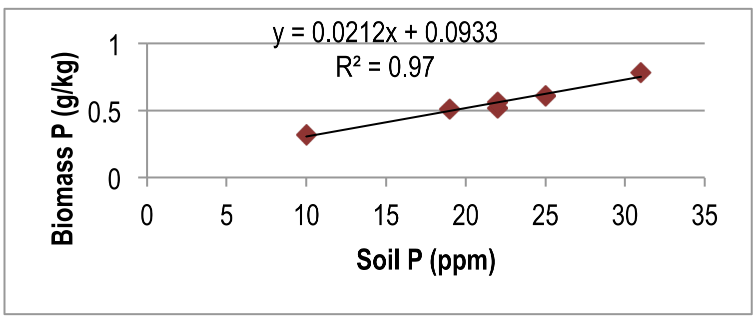
*, ** nutrient effect on tissue composition significant at the 5 and 1% levels of probability, respectively.

  - Concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), and biomass ash were unaffected by N or P/K nutrition.

  - Soluble sugars were unaffected by N, but were reduced by both P and K fertilizers.

- Significant interactions among N, P, and K were identified for some variables. Details are available upon request (Contact J.J. Volenec or S.M. Brouder at Purdue University Dept. of Agronomy; jvolenec@purdue.edu or mailto:sbrouder@purdue.edu.

- **Mineral analyses at the TPAC switchgrass Factor Analysis Plots have been completed** on soils with varying levels of soil P and K. Biomass yield was not influenced by soil or tissue biomass P and K concentrations. Biomass P and K concentrations reflected differences in soil test P and K. Soil P is an excellent predictor of switchgrass biomass P concentration. Soil K is a fair predictor of switchgrass biomass K concentration.



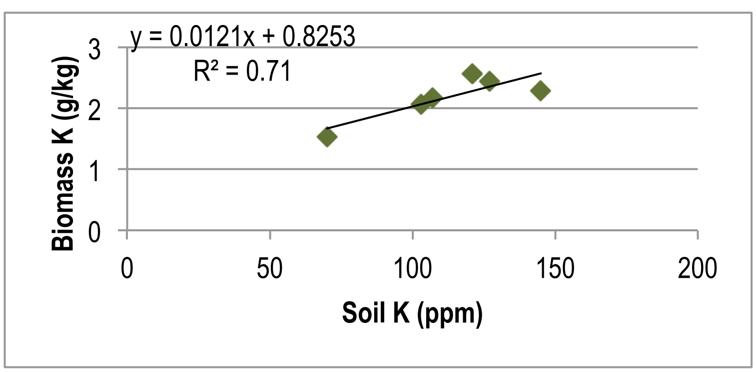


Figure 7. Soil P and K (ppm) predicted switchgrass tissue P and K concentrations (g/kg)

- **USDA-ARS, Lincoln, Nebraska**

- ✓ **Factor Analysis Plots.** Factor Analysis Plots seeded in 2012 and 2013 in Nebraska had excellent stands in 2012 and 2013 despite one of the most severe droughts on record. Fertilizer and harvest treatments have been initiated in 2013 on the 2012 plots. 2013 stands are good, but bioenergy big bluestem stand counts are low. The 2012 feedstock samples from NE and Minnesota are ready for NIRS analysis.

Table 17. Percent stand in 2012 and 2013 of plots of switchgrass (Liberty, Shawnee), the low-diversity (LD) mixture, big bluestem and the bioenergy mixture seeded in 2012 and 2013.

Stand Counts (%)	Liberty switchgrass	Shawnee switchgrass	LD mixture	Bioenergy big bluestem	Bioenergy mixture
2012 plots in 2012	52	65	42	32	49
2012 plots in 2013	68	58	72	68	54
2013 plots in 2013	77	89	52	28	51

- ✓ **System Analysis Plots.** System Analysis Plots seeded in Nebraska in 2012 had excellent 2012 and 2013 stands despite severe drought which demonstrates that perennial warm-season grasses are productive, even in extreme drought. Fertilizer and harvest treatments have been initiated. Corn yield in 2012 was 102 bu/acre with 1.44 tons/acre of stover. Plots will be harvested with field-scale equipment after killing frost. Perennial grass biomass has been collected once per week throughout the growing season to provide biomass accumulation data and feedstock characterization. Based on discussions at the 2013 CenUSA Annual meeting, a harvest-height study (2, 4, 6, 8, 10, and 12 inches) was initiated in 2013 to determine feedstock response to harvest height and date (at anthesis and after killing frost).

Table 18. Percent stand and biomass yield in both 2012 and 2013 of Liberty switchgrass, big bluestem and the low-diversity (LD) mixture.

Feedstock	2012 Stands (%)	2013 Stands (%)	2012 Biomass Mg/ha	2013 Biomass Mg/ha
Liberty Switchgrass	84	87	7.6	18.5
Big bluestem	68	79	2.7	12.7
LD Mixture	60	78	4.3	14.5
Liberty Switchgrass	84	87	7.6	18.5

- ✓ **GHG Sampling.** GHG sampling was initiated in 2013. We sampled GHG, soil water content, and biomass at weekly intervals in the Nebraska System Analysis Plots.

Cumulative growing season emissions through July 11, 2013 indicated total N_2O emissions from corn are 4-5 times higher than emissions from any grass system. Large N_2O emissions in corn were associated with the timing and amount of precipitation. N treatments in grasses did not affect total N_2O emissions. CO_2 emissions were ~30% lower in continuous corn compared to bioenergy grasses.

- ✓ Indirect biomass measurements have been conducted on the Nebraska System Analysis and all demonstration plots. Visual obstruction (VOM) and elongated leaf height (ELH) have been measured with the grassland assessment tool to evaluate indirect methods for estimating biomass yields in perennial feedstocks. Predicting the current and end-of-season biomass yields quickly and accurately will help estimate biomass supplies. Our objective is to develop regression equations to determine how well VOM and ELH predict standing biomass.

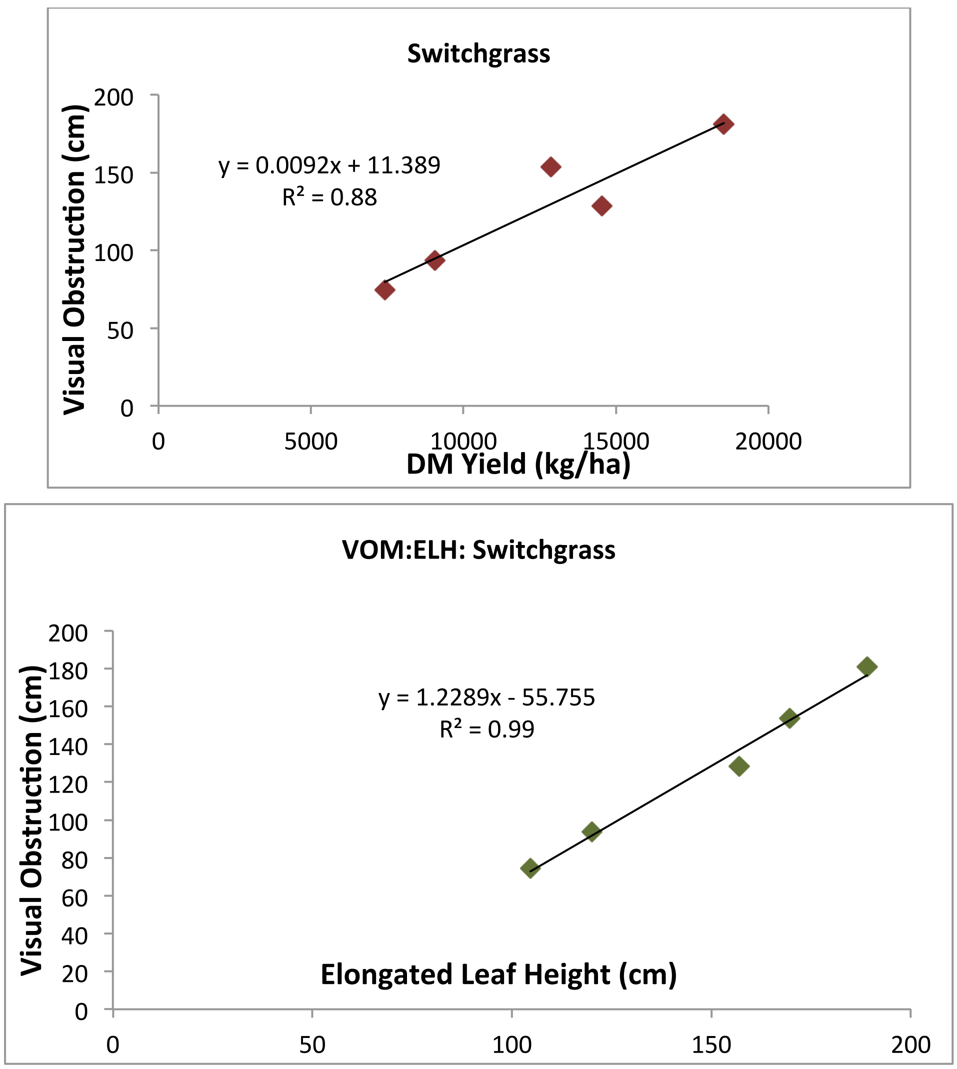


Figure 8. VOM and ELH were excellent predictors of switchgrass biomass and are strongly correlated

- ✓ **Collaborations**

  - We are working with the CenUSA *System Performance Metrics, Data Collection, Modeling, Analysis and Tools* objective (Objective 4) to conduct a field day in Wisconsin on September, 19, 2013 (weather dependent) to show-case herbaceous perennial feedstock establishment.

  - We created a fact sheet, *Establishing and Managing Perennial Grass Energy Crop Demonstration Plots*, on establishing bioenergy demonstration sites authored by Rob Mitchell, Jeff Volenec, and Pam Porter which is available on the CenUSA web site at: https://www.cenusa.iastate.edu/PublicFile/_GetPublicFile?publicFileId=67

  - We distributed frequency grids to the demonstration site coordinators.

  - We burned the 2012 Nebraska Demonstration site, re-seeded thin spots in the stand, and seeded the 2013 Nebraska Demonstration site.

Photo 6. Southeast Nebraska Demo Site. Due to drought in 2012 the CenUSA Extension Switchgrass Demonstration plots had only moderate to poor establishment. The team decided to perform a prescribed burn in the spring of 2013 to help with stand 2013 establishment. Burns help by removing above ground biomass giving new seedlings better access to sunlight and causes the soil to warm sooner favoring warm season grasses, plus slows cool season weed grown. (John Hay)

  - We worked with the National Wildlife Federation to develop best management guidelines for perennial grasses for bioenergy.

  - We shipped switchgrass bales to Iowa State University for distribution to industry partners.

- We attended the Sun Grant Switchgrass Meeting to develop a national switchgrass yield map for both upland and lowland strains.

- We attended the Energy Biosciences Feedstocks Symposium to present research updates on switchgrass.

- **USDA-ARS, Madison, Wisconsin**

✓

✓ Completed the first 2013 harvest at peak biomass.

✓ Main goals for next quarter are to harvest plots, measure biomass yield, and collect quality samples for the next two harvest dates.

3. Explanation of Variance

No variance has been experienced at any location and accomplishments are on schedule.

4. Plans for Next Quarter

- Complete laboratory analyses of soils and plant tissues from previous sampling campaigns.
- Where stands are sufficient, harvest biomass at Factor Analysis and Systems Plots.
- Dry and process samples for analysis.
- Where appropriate, sample soils for analysis.
- Dry and grind soils for analysis.
- Collaborate with CenUSA partners in other Objectives (e.g., Feedstock Development and Extension and Outreach).
- Begin entering data and initiate preliminary data analysis.
- Participate in regional and national conferences as appropriate to report findings.

5. Publications, Presentations, and Proposals Submitted

- Woodson, P, Volenec, J.J. & Brouder, S.M. (2013). Field-scale potassium and phosphorus fluxes in the bioenergy crop switchgrass: Theoretical energy yields and management implications. *J. Plant Nutr. Soil Sci.* 176:387-399.

- Trybula, E.T., Cibin, R., Burks, J.L., Chaubey, I., Brouder, S.M. & J.J. Volenec. (2013). Perennial rhizomatous grasses as bioenergy feedstock in SWAT: parameter development and model improvement. *Engineer. Sci. Tech.* (submitted).

Objective 3. Feedstock Logistics

The Feedstock Logistics Objective focuses on developing systems and strategies to enable sustainable and economic harvests, transportation and storage of feedstocks that meet agribusiness needs. The team also investigates novel harvest and transport systems and evaluates harvest and supply chain costs as well as technologies for efficient deconstruction and drying of feedstocks.

Iowa State University

1. Planned Activities – Iowa State University

Research activities planned during the fall of 2013 included:

- Completion and testing of lab scale equipment to study unit operations in the harvest, storage and transportation of perennial grasses. The objective is to have the system completed and tested prior to the fall harvest period, when experimental data will be collected.

- Collection of field scale machine performance and logistics data for large-scale harvest and transportation of perennial grasses. The objective is to instrument all the machines of large custom hay and forage operations to collect reliable machine performance data for modern large-scale machines.

2. Actual Accomplishments – Iowa State University

- Laboratory scale equipment to provide a controlled environment, in which dry matter loss during field and storage operations can be studied, has been built and will be used this fall for tests. The system is capable of controlling air temperature, air speed, relative humidity and radiation intensity. The system will be used to evaluate different ambient conditions and harvesting/condition methods on biomass drying and losses. The objective is to develop improved dry matter loss models that can then be integrated into field harvest and logistics cost models.

- We are in discussion with two companies, Vermeer and Poet, for collection of field scale machine performance and logistics data for large-scale harvest and transportation of biomass for fall 2013. The plan is to instrument all the machines of large-scale baling and transportation operations and to collect reliable machine performance data for modern large-scale machines.

3. Explanation of Variance – Iowa State University

- No significant variance has been experienced –we accomplished all that we had planned during this project period.

4. Plans for Next Quarter – Iowa State University

Research activities planned during next quarter include:

- Analysis of data collected from laboratory experiments to evaluate different ambient conditions and harvesting/condition methods on biomass drying and losses. Development of improved dry matter loss models that can then be then be integrated into field harvest and logistics cost models.

- Analysis of field scale machine performance and logistics data for large-scale harvest and transportation of perennial grasses collected during fall harvest.

5. Publications, Presentations, and Proposals Submitted – Iowa State University

None to report this period.

University of Wisconsin, Madison

1. Planned Activities – University of Wisconsin, Madison

Research activities planned included:

- Analysis of data collected in 2012;

- Management of the bale storage study;

- Development of machine configurations to combine cutting/intensive conditioning/tedding;

- Collection of post-storage size-reduction energy requirements of bales; and

- Establishment of native grass fields for demonstration and research use.

2. Actual Accomplishments – University of Wisconsin

Bales were placed into storage in the fall of 2012 to investigate means to reduce DM losses from dry bales stored outdoors. Four treatments were considered in this dry bale study, including indoor and outdoor storage and bales wrapped in plastic film (either individually or in a tube). Bales were removed from storage in July. Loss of DM in storage and spatial moisture distribution were quantified. Bale stored indoors and wrapped in a film tube had losses of DM of less than 2 percent of totals stored. Losses exceeded 5 percent of total for all other treatments.

In 2012, we determined that both intensive conditioning and wide-swath drying enhanced the drying rate of switchgrass. We have begun development of a machine configuration to combine cutting/intensive conditioning/tedding into a single operation. This system will involve a mower front-mounted on a tractor which will also pull a towed intensive conditioner equipped with a mounted tedder. We have arranged for loan of a tractor and mower to accomplish the first operations and have now acquired an intensive conditioner and tedder. The re-configuration is now capable of completing three operations – cutting, intensive conditioning and wide-swath tedding in a single-pass, eliminating two field operations. Initial functional tests were conducted using alfalfa and reed canary grass in June and July 2013. The tri-function machine performed well with both crops, although leaf loss was excessive when harvesting alfalfa.

We continue to quantify the energy required to size-reduce perennial grasses post-storage. Our work during the previous three months was focused on grinding round bales of grasses. Grinding bales requires two to three times the specific fuel consumption of chopping with a forage harvester while producing a slightly less favorable particle-size distribution. One reason for this is the poor feeding characteristics of bales into the size-reduction mechanism on the grinder. We hypothesized that bales that were pre-cut during baling would have more favorable feeding characteristics in the grinder, reducing energy required for size-reduction. This was in fact the case as pre-cutting significantly improved throughput, size-reduction, and fuel consumption.

Several fields of grass and straw were round baled and bales were either randomly distributed or strategically accumulated in one field location with a baler equipped with a two-bale accumulator. An experienced operator loaded the bales onto trailers and bale handling was quantified by time, distance traversed, and fuel use per bale. Accumulating bales had greater impact on bale handling expenditures when only one operator was used for both bale handling and trailer positioning and when fields were irregularly shaped with difficult terrain. When a second person was available to strategically move the trailer in the field during loading and when the field is flat and well shaped, bale accumulation resulted in less saving.

Finally, we have rented 32 acres of marginal land in which we will establish a variety of perennial grasses. Rob Mitchell (CoProject Director, Objective 2) has provided valuable input on the type and variety of grasses. The fields have been planted in mixtures of switchgrass, big bluestem, and indiangrass. Switchgrass has established well but weed pressure is significant in the native grass fields. A grass establishment outreach field day has been scheduled for September 19th. Rob Mitchell will lead the discussion on proper techniques to ensure grass establishment success.

3. Explanation of Variance – University of Wisconsin

There were no variances – we have accomplished all that we had planned.

4. **Plans for Next Quarter – University of Wisconsin**

We plan to:

- Analyze 2013 data and prepare manuscripts for publication;
- Conduct a second bale storage study;
- Conduct evaluation of the combined cutting/intensive conditioning/tedding machine using switchgrass;
- Collect post-storage size-reduction energy requirements of bales removed from storage; and
- Continue establishment of perennial grasses on rented acreage and conduct an outreach field day.

5. **Publications, Presentations, and Proposals Submitted – University of Wisconsin**

- Shinners, K.J. & Friede, J.C. (2013). Improving the drying rate of switchgrass. ASABE Technical Paper No. 1591968. Presentation to the 2013 ASABE International Meeting, Kansas City, MO, August 21 – 24, 2013.
- Shinners, K.J. & Friede, J.C. (2013). Energy requirements for at-harvest or on-farm size-reduction of biomass. ASABE Technical Paper No. 1591983. Presentation to the 2013 ASABE International Meeting, Kansas City, MO, August 21– 24, 2013.
- Shinners, K.J., Friede, J.C., Kraus, T.J. & Anstey, D. (2013). Improving bale handling logistics by strategic bale placement. ASABE Technical Paper No. 1591987. Presentation to the 2013 ASABE International Meeting, Kansas City, MO, August 21– 24, 2013.

Objective 4. System Performance Metrics, Data Collection, Modeling, Analysis and Tools

This research team focuses on providing detailed analyses of feedstock production options and an accompanying set of spatial models to enhance the ability of policymakers, farmers, and the bioenergy industry to make informed decisions about which bioenergy feedstocks to grow, where to produce them, what environmental impacts they will have, and how biomass production systems are likely to respond to and contribute to climate change or other environmental shifts.

Iowa State University (ISU)

1. **Planned Activities (ISU)**

The first two broad tasks under the System Performance Objective are to adapt existing biophysical models to best represent field trials and other data and to adapt existing economic land-use models to best represent cropping system production costs and returns.

2. **Actual Accomplishments (ISU)**

A major component of the Objective's ISU-CARD modeling work involves the improvement of SWAT models for the Upper Mississippi River Basin and the Ohio Tennessee River Basin with USGS 12-digit subwatersheds. There is now a much denser subwatershed delineation; e.g., 5,279 12-digit subwatersheds versus 131 8-digit subwatersheds for the UMRB. This modeling structure will provide the ability to perform enhanced scenarios including greatly refined targeting scenarios to study placement of switchgrass and other biofuel crops in the landscape to evaluate the water quality and carbon effects at the landscape level.

Initial calibrations of the model are complete. We have moved into a phase of in-depth testing of the *Upper Mississippi River Basin* (UMRB) and *Ohio-Tennessee River Basin* (OTRB) SWAT models. We successfully completed an analysis of the impacts of several corn-system scenarios on water quality within the UMRB for both historical climate conditions as well as for a future climate projection. This provides important baseline information for future analyses.

3. **Explanation of Variance (ISU)**

No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter (ISU)**

We will continue work on the first two tasks:

- **Task 1**. We will continue to adapt existing biophysical models to best represent field trials and other data.

- **Task 2**. We will continue to adapt existing economic land-use models to best represent cropping system production costs and returns. We are beginning to develop scenarios using our integrated SWAT model to assess the fuel production and water quality effects of large-scale water quality.

5. **Publications, Presentations, and Proposals Submitted (ISU)**

- Kling, C. L. (2012, December) *The Potential for Agricultural Land Use Changes in the Raccoon River Basin to Reduce Flood Risk: A Policy Brief for the Iowa Flood Center.* Presentation to the University of Iowa Hydraulics Laboratory, Iowa City, Iowa available at http://www.card.iastate.edu/environment/presentations.aspx

- González-Ramírez, J., Kling, C. L. & Valcu, A.M. (2012) An Overview of Carbon Offsets from Agriculture. Forthcoming in the *Annual Review of Resource Economics*

Vol. 4, October 2012. Review in advance available at http://www.annualreviews.org.proxy.lib.iastate.edu:2048/doi/abs/10.1146/annurev-resource-083110-120016.

- Gonzalez-Ramirez, J., Valcu, A. M. & Kling, C.L. (2012). An Overview of Carbon Offsets from Agriculture. *Annual Review of Resource Economics* 4: 145-160. Available at http://www.nature.com/nclimate/journal/v2/n3/full/nclimate1346.html.

- Kling, C. L. (2013, August). Optimal placement of Second Generation Biofuels in a Watershed: Is Marginal Land the Answer? Presentation to the annual meeting of *the Association of Agricultural and Applied Economics*.

- Kling, C. L. (2013, January). Water Quality: Corn vs. Switchgras. Presentation to the *Roundtable on Environmental Health Sciences, Research, and Medicine* "The Nexus of Biofuels Energy, Climate Change, and Health" Institute of Medicine, National Academy of Sciences.

- Kling, C. L. National Science Foundation. Climate and Human Dynamics as Amplifiers of Natural Change: A Framework for Vulnerability Assessment and Mitigation Planning, (Principal Investigator), 2012-2016. $480,000.

- Schilling, K. E., Gassman, P.W., Kling, C. L., Campbell, T., Jha, M., Wolter, C.F. & Arnold, J.G. (2013). The Potential for Agricultural Land Use Change to Reduce Flood Risk in a Large Watershed. *Hydrological Processes* (2013) Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/hyp.9865

- Rabotyagov, S., Valcu, A. M. and Kling, C. L. (2012, December 12-13). Reversing the Property Rights: Practice-Based Approaches for Controlling Agricultural Nonpoint-Source Water Pollution When Emissions Aggregate Nonlinearly. Presentation to the Global Environmental Challenges: The Role of China Shanghai, China.

- Valcu, A.M. (2013). Agricultural Nonpoint Source Pollution and Water Quality Trading: Empirical Analysis under Imperfect Cost Information and Measurement Error. PhD dissertation, Iowa State University.

- Markets and Regulation: Alternative or Complements. (2012, February). Presentation to the *2012 Agricultural Outlook Forum*, sponsored by USDA, Washington DC, presentation available at http://www.card.iastate.edu/environment/presentations.aspx
- The Potential for Agricultural Land Use Changes in the Raccoon River Basin to Reduce Flood Risk: A Policy Brief for the Iowa Flood Center, presentation available at http://www.card.iastate.edu/environment/presentations.aspx

University of Minnesota (UMN)

1. Planned Activities (UMN)

Planned activities for this quarter include continued work on:

- Task 1. Adapt existing biophysical models to best represent data generated from field trials and other data sources.

- Task 2. Adapt existing economic land-use models to best represent cropping system production costs and returns.

- Task 3. Integrate physical and economic models to create spatially explicit simulation models representing a wide variety of biomass production options.

- Task 4. Evaluate the lifecycle environmental consequences of various bioenergy landscapes.

2. Actual Accomplishments (UMN)

Our major accomplishment for the fourth quarter of Project Year 2 was the publication of our paper comparing U.S. federal agency bioenergy feedstock production scenarios for achieving Renewable Fuel Standard (RFS2) biofuel volumes. Our analysis of switchgrass and corn trial yields in our investigation of yield gaps continued, as did our compilation of production cost and return data for switchgrass, exploration of different biodiversity models for use in our InVEST modeling, and writing of scripts to automate the modeling of biomass production placement on the landscape. In addition, graduate students and postdocs attended the Education Objective's summer Intensive Program (IP).

3. Explanation of Variance (UMN)

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter (UMN)

Next quarter will include continued work on Tasks 1, 2, and 3, and 4.

5. Publications, Presentations, and Proposals Submitted (UMN)

- Anderson-Teixeira, K. J., P. K. Snyder, T. E. Twine, S. V. Cuadra, M. H. Costa, E. H. DeLucia. (2012). Climate regulation services of natural and agricultural ecoregions of the Americas. *Nature Climate Change, 2*: 177-181. doi:10.1038/nclimate1346. Available at http://www.nature.com/nclimate/journal/v2/n3/full/nclimate1346.html.

- Hill, J. (2013, January). Evaluating lifecycle impacts of biomass production for bioproducts and bioenergy. Catalysis Center for Energy Innovation, Minneapolis, MN.

- Hill, J. (2013, February). Green engineering – The future. Presentation to the Society of Women Engineers Region H Conference, Minneapolis, MN.

- Hill, J. (2013, January). Biofuels: Lifecycle impacts on land and air. Workshop on the Nexus of Biofuels Energy, Climate Change, and Health, Institute of Medicine of the National Academies, Washington, DC.

- Keeler, B., Krohn, B., Nickerson, T., Hill J. (2013) U.S. Federal Agency Models Offer Different Visions for Achieving Renewable Fuel Standard (RFS2) Biofuel Volumes. *Environ. Sci. Technol.* DOI: 10.1021/es402181y. (Cover feature).

Post-Harvest Research Group

- Robert Brown, Director of Iowa State University's bio economy Institute leads the post harvest research group.

The Post-Harvest group focuses on three project objectives:

- Feedstock Conversion/Refining

- Markets and Distribution

- Health and Safety

Objective 5. Feedstock Conversion and Refining: Thermo-chemical Conversion of Biomass to Bio-fuels

The Feedstock Conversion and Refining objective will perform a detailed economic analysis of the performance of a refinery based on pyrolytic processing of biomass into liquid fuels and will provide biochar to other CenUSA researchers. The team concentrates on two primary goals:

- Estimating energy efficiency, GHG emissions, capital costs, and operating costs of the proposed biomass-to-biofuels conversion system using technoeconomic analysis; and

- Preparing and characterizing Biochar for agronomic evaluations.

Sub-objective 1: Perform Technoeconomic Analysis (TEA)

1. **Planned Activities**

   Develop a catalytic pyrolysis process model. Develop experimental plan to test mild catalytic pyrolysis.

2. **Actual Accomplishments**

Simulations of catalytic pyrolysis of red oak, for which experimental data is available to support the analysis, have been completed. Using these results a technoeconomic analysis (TEA) has been performed and a paper submitted to a special issue of Green Chemistry.

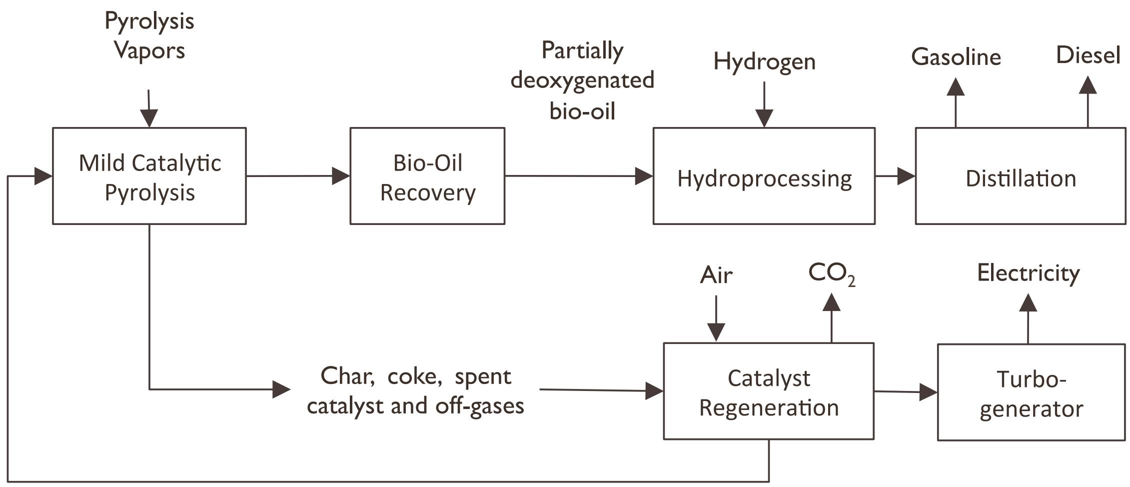


Figure 9. Process flow for mild catalytic fast pyrolysis to drop-in fuels

Table 19. Technoeconomic summary of mild catalytic pyrolysis to drop-in fuels	
Fuel Output	38.5 MGY
Electricity Output	254 million kWh
Capital Cost	$454 million
MFSP[1]	$3.68/gal
Minimum fuel selling price; assumes $82.MT woody biomass and 10% IRR	

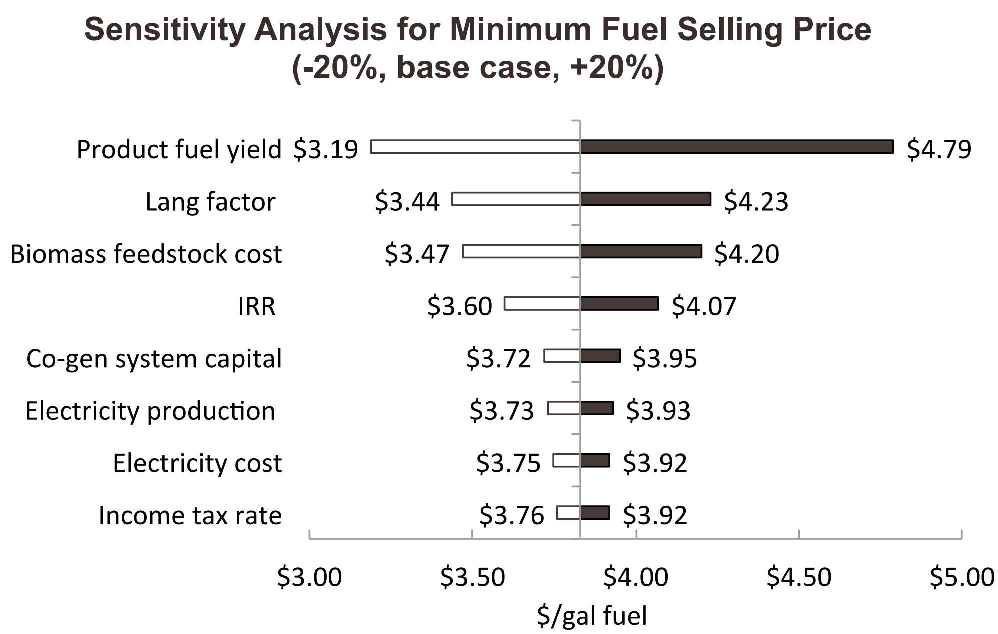


Figure 10. Sensitivity Analysis of mild catalytic pyrolysis to drop-in fuels

Experimental pyrolysis data is being collected on switchgrass, which will allow a similar TEA to be performed on this preferred feedstock. These experiments are utilizing commercially available zeolite catalysts and are being performed in standard and Tandem Frontier Micropyrolysis units.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

Continue micropyrolysis experiments to provide inputs to process models.

Complete editing and submit the Bohem titration manuscript for publication. Conduct X-ray fluorescence analysis to quantify inorganic compounds in the ash of biochars.

Sub-objective 2: Prepare and Characterize Biochar

1. Actual Accomplishments

A manuscript documenting the effects of ash and soluble organic compounds in biochars on results of Bohem titrations and proposing an improved Bohem titration procedure was submitted to the *Journal of Environmental Quality (JEQ)*. X-ray fluorescence analysis of inorganic compounds in a diverse group of biochars was completed. The XRF results were combined with results from previous thermal combustion analysis to obtain a complete elemental analysis of the biochars with oxygen determined by difference. The results are summarized below in Figures 11 and 12 showing the effect of laboratory aging (4 months with H_2O_2 at high pH), peak pyrolysis temperature, and type of biomass feedstock on average elemental and oxide compositions and a van Krevelen plot (molar ratios of H/C vs O/C).

The results indicate that both aging and metal pre-treatments can be used to increase the oxygen content of corn stover and alfalfa biochars. By contrast, aging treatments and metal pre-treatments had only a small effect on the oxygen content of the cellulose biochar. Oxygen content of biochars is an indicator of polar organic functional groups on biochar surfaces, which have a major influence on the ability of biochar to retain both water and nutrients in soil environments.

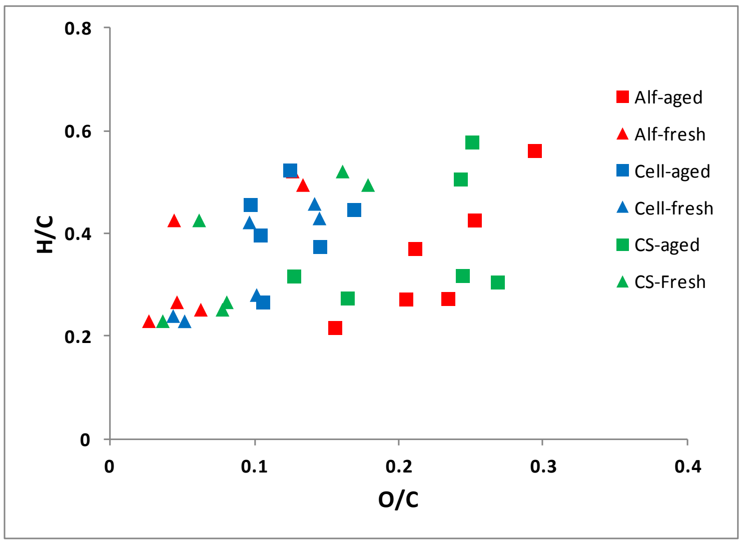


Figure 11. Effects of laboratory aging on molar H/C and O/C ratios

2. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

3. Plans for Next Quarter

We have recently received reviews back from JEQ on the Boehm titration paper. This next quarter we will be revising the Boehm titration manuscript to address the reviewer comments before returning the manuscript to JEQ for a final decision on publication. During the next quarter we will work on data analysis and interpretation for a biochar characterization manuscript. We anticipate having to reanalyze several samples by X-ray diffraction and

FTIR to complete the date set needed for the manuscript. A first draft of the biochar characterization manuscript will be written.

Mass %	Aging treatment	Feedstock		
		Cellulose	Corn stover	Alfalfa
C	Aged	79.90	67.22	63.72
O	Aged	13.19	19.13	19.04
N	Aged	0.00	0.64	3.42
H	Aged	2.73	2.12	1.85
S	Aged	0.05	0.08	0.14
Cl	Aged	0.11	0.13	0.13
Fe2O3	Aged	1.56	0.84	0.73
Al2O3	Aged	0.75	0.81	0.73
CaO	Aged	1.01	1.87	6.37
MgO	Aged	0.14	1.06	1.27
K2O	Aged	0.01	0.18	0.15
SiO2	Aged	0.04	5.59	1.83
P2O5	Aged	0.00	0.21	0.53
C	Fresh	82.15	70.87	70.87
O	Fresh	10.34	9.08	6.69
N	Fresh	0.00	1.39	1.39
H	Fresh	2.31	2.12	2.12
S	Fresh	0.09	0.09	0.09
Cl	Fresh	1.27	3.44	6.61
Fe2O3	Fresh	1.71	0.57	0.40
Al2O3	Fresh	0.89	0.75	0.72
CaO	Fresh	0.36	1.20	2.93
MgO	Fresh	0.16	1.13	1.33
K2O	Fresh	0.01	2.22	4.24
SiO2	Fresh	0.04	6.83	2.01
P2O5	Fresh	0.00	0.22	0.51

Mass %	Py temp (° C)	Pre-treatment		
		Control	Al-tret	Fe-treat
C	500	75.95	67.69	68.55
O	500	11.12	16.90	15.94
N	500	1.21	1.46	1.41
H	500	2.54	2.87	2.52
S	500	0.07	0.06	0.08
Cl	500	0.43	2.61	2.37
Fe2O3	500	0.09	0.28	2.32
Al2O3	500	0.09	1.88	0.08
CaO	500	2.79	1.74	2.20
MgO	500	0.92	0.69	0.70
K2O	500	1.54	0.84	0.96
SiO2	500	2.88	2.45	2.46
P2O5	500	0.27	0.19	0.22
C	700	77.74	71.93	72.86
O	700	9.36	12.19	11.94
N	700	0.97	0.92	0.88
H	700	1.85	1.66	1.80
S	700	0.11	0.10	0.11
Cl	700	0.54	3.11	2.64
Fe2O3	700	0.10	0.57	2.46
Al2O3	700	0.10	2.42	0.09
CaO	700	2.95	1.95	2.12
MgO	700	1.16	0.85	0.77
K2O	700	1.63	0.87	0.97
SiO2	700	3.04	2.72	2.78
P2O5	700	0.32	0.23	0.25

Figure 12. Effects of metal pretreatment, aging, and pyrolysis temperature on biochar composition

4. Publications, Presentations, and Proposals Submitted

None

Objective 6. Markets and Distribution

The Markets and Distribution objective recognizes that a comprehensive strategy to address the impacts to and requirements of markets and distribution systems will be critical to the successful implementation and commercialization of a regional biofuels system derived from perennial grasses grown on land unsuitable or marginal for the production of row crops. To create this comprehensive strategy the team focuses on two unifying approaches:

- The study and evaluation of farm level adoption decisions, exploring the effectiveness of policy, market and contract mechanisms that facilitate broad scale voluntary adoption by farmers; and

- Estimate threshold returns that make feasible biomass production for biofuels.

Iowa State University

1. Planned Activities

The team had four anticipated activities for the fourth quarter Project Year 2 (Y2 Q4):

- Prepare for the CenUSA Intensive Program held in Ames, Iowa during June, 2013.
- Prepare for the CenUSA Bioenergy Annual Meeting held in West Lafayette, Indiana during July 2013.
- Continue development of the spatial model of biomass supply with heterogeneous producers (Perrin).
- Continue to interact with industry on an Iowa State University Bioeconomy Institute project to model the use of feedstocks as a fuel source for fast pyrolysis. The business model involves a distributed system of fast pyrolysis that provides as byproducts char and bio-oil. Char will be sold as a soil amendment, and bio-oil will be sold for use in furnaces for heat. The group includes soil scientists, chemical engineers and mechanical engineers (Hayes).
- Complete modeling and analysis efforts of the regional supply curve for grasses and stover using a real options framework (Hayes). Present one of these at an international conference on this subject in late June 2013. Publish two peer-reviewed papers in this area.

2. Actual Accomplishments

- Keri Jacobs presented a report at the CenUSA Bioenergy Annual meeting. There was much interest from the group – researchers, stakeholders, and advisory board – in the results of the producer survey administered during the Iowa State University Integrated Crop Management event. Jacobs will follow up with extension personnel to develop a strategy for administering this survey on a wider scale so that feedback from producers outside of Iowa can be gathered.
- Richard Perrin completed his analysis of yields from switchgrass field trials in the CenUSA study area, covering 10 states and 49 varieties. An initial draft of a report has been prepared.
- We are continuing to interact with industry on an Iowa State University Bioeconomy Institute project to model the use of feedstocks as a fuel source for fast pyrolysis.

- The analysis is not yet complete for the regional supply curve for grasses and stover using a real options framework; however, preliminary results and modeling efforts have been shared with the group. The expectation is that peer-reviewed papers will be published as a result of this work.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter – Iowa State University

During the first quarter of Project Year 3 (Aug. – Oct. 2013), our team will work toward the following:

- Jacobs will work with the CenUSA extension objective to develop plans to administer the "Adoption of Switchgrass Production Survey." As with the pilot survey administered during the first quarter of Project Year 2 and analyzed during the 2nd and 3rd quarters, the survey results will be reported to the group. Recommendations for extension programs related to the CenUSA effort will then be developed over several quarters.

- We will continue to interact with industry on a BEI project to model the use of feedstocks as a fuel source for fast pyrolysis. The business model involves a distributed system of fast pyrolysis that produces char and bio-oil. Char will be sold as a soil amendment, and bio-oil will be sold for use in furnaces for heat. The group includes soil scientists, chemical engineers and mechanical engineers (Hayes).

- We will continue our modeling and analysis efforts of the regional supply curve for grasses and stover using a real options framework (Hayes). We will present one of these at a conference on this subject in 2013/2014. We anticipate publishing two peer-reviewed papers in this area.

- We will construct the budgeting analysis of threshold returns necessary to make biomass production feasible under various yield regimes and land use alternatives (Perrin).

5. Publications, Presentations, and Proposals Submitted

Perrin completed a study of the potential impact of higher grain and hay prices on the allocation of crop acreage (Megeressa 2013 *Impact of Biofuel Demand on Land and Water Use in the Great Plains*[4]). From a study of Nebraska county-level data, we estimate that a 20 percent increase in grass hay price can be expected to increase grass hay acreage by only 4 percent, mostly at the expense of wheat and alfalfa acreage, suggesting that substantial incentives will need to be provided for biomass grasses to divert significant acreages from

[4] The publication is available at DigitalCommons@University of Nebraska – Lincoln: http://digitalcommons.unl.edu/dissertations/AAI3559163/

current crops. An analysis of state-level data for Nebraska, Kansas and Oklahoma, 1960-2004 generally supports this conclusion, indicating that area devoted to grass hay and pasture has not been significantly responsive to hay prices. Response of the quantity of hay actually harvested in response to prices remains to be examined.

Objective 7. Health & Safety

The production of bioenergy feedstocks will have inherent differences from current agricultural processes. These differences could increase the potential for workforce injury or death if not properly understood and if effective protective counter measures are not in place.
The Objective 7 team addresses two key elements in the biofuel feedstock supply chain:

- The risks associated with producing feedstocks; and
- The risks of air/dust exposure.

1. Task 1 – Managing Risks in Producing Feedstocks

a. Planned Activities

The team is adjusting the collection of the various tasks associated with producing biofeedstocks by creating a formal structure of tasks and steps with a deliberate hierarchy. The major headings for main tasks are listed as:

- **Establishment** (with seed bed preparation, weed control and planting);
- **Maintaining** (weed control);
- **Harvest**;
- **On-site processing and storage** (stacking); and
- **Transportation**.

The different risk assessment methods are being evaluated for those established tasks.

b. Actual Accomplishments

We have made fair progress in refining the accumulated listing of tasks/responsibilities for biofeedstock production. The listing is currently identified as 7 Main Tasks, 15 Task Groupings, 112 Tasks, and 371 Actions. Actions are the lowest level where potential risks are discernible and where the different risk assessment methods will be applied. It is also noted that some “Actions” are duplicated in various Task and Task Groupings. We cataloged the various types of equipment currently being used on plots and fields maintained by the project staff . The diversity of equipment is fairly common as expected in most operations. The type, horsepower, etc. are critical elements needed for assessing risk for most "Actions."

Three risk assessments tools for handling the evaluation of the various tasks were identified. They are: "Frequency/Severity Analysis", "Deviation Analysis", and "Fault Tree Analysis." Each "Action" will be assessed using these three tools.
The team reinforced the cooperative arrangement with the investigator at Penn State University that is also working with another biofuel project to collaborate in developing a standard to assess risk in these types of tasks. The data of the formal structure of tasks was shared. Collaboration for two presentations at the 2013 North American Agricultural Safety Summit occurred.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

We will continue refining the accumulated listing of Main Tasks/Task Grouping/Tasks/Actions. Assessment of the three risk assessments tools for handling the evaluation of the various Actions will be made. It is expected that the standard risk assessment tool to use for tasks in biofeedstock production might be a hybrid of the three under investigation.

e. Publications, Presentations, and Proposals Submitted

A presentation has been submitted for the Biomass and Biofuels session of the 2013 North American Agricultural Safety Summit hosted by Agricultural Safety & Health Council of America. The summit will be held in Minneapolis, Minnesota on September 25-27, 2013.

Previous publication submitted: Schwab, C. V., and M. Hanna. 2012. Master Gardeners' safety precautions for handling, applying, and storing biochar. CenUSA Bioenergy publication. ISU University Extension and Outreach, Ames, Iowa 50011.

2. Task 2 – Assessing Primary Dust Exposure

a. Planned Activities
The locations for dust exposures have been compiled and those currently identified are being examined for determination of the most likely place to find the highest hazardous exposure rates. This will be the selection process to determine where the pilot analysis of actual dust exposure will take place.

b. Actual Accomplishments

The prioritized locations for dust exposures were evaluated and the primary locations to be measured will be located in the seedbed preparation and harvesting operations. Literature review indicated that there was very little published research on respriable dust in agricultural operations, however it clearly indicated these operations were the most likely to have respriable dust exposures. The identification of the monitoring equipment needed to take dust samples was identified as a 10-mm nylon cyclone and 5-um PVC filter to an air sampling pump running at 1.7 L/min. This will collect total and respriable dust. The exact details of the subject and plot location are not confirmed at this report, but are expected before next.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

We will obtain approvals for human subjects research. Data for priority or first few sample sites will be collected during the harvesting operations.

e. Publications, Presentations, and Proposals Submitted

None to report this period.

EDUCATION, OUTREACH AND EXTENSION RESEARCH GROUP

Jill Euken, Deputy Director of Iowa State University's BioEconomy Institute leads the Education, Outreach and Extension Research Group.

The group focuses on two project objectives:

- Education
- Extension and Outreach

Objective 8. Education

The Education Objective 8 seeks to meet the future workforce demands of the emerging Bioeconomy through two distinct subtasks, as follows:

- To develop a shared bioenergy core curriculum for the Central Region, and
- To provide interdisciplinary training and engagement opportunities for undergraduate and graduate students.

Subtask 1 is curriculum development. Subtask 2A involves training undergraduate students via an 8-week summer internship program modeled on the highly successful NSF REU (research experience for undergraduates) program.

Subtask 2B involves training graduate students via a two week summer intensive program modeled on a highly successful industry sponsored intensive program in biorenewables the team led in 2009.

Subtask 2C is training graduate students via a monthly research webinar. The next portion of this report is broken into subtasks.

Subtask 1: Curriculum Development

1. Planned Activities – Curriculum Development

- **Module 3. Perennial Grass Harvest Management**
  - ✓ We will submit machinery lessons to the *Journal of Natural Sciences Education* for peer review.
  - ✓ We will continue module development activities with Amy Kohmetscher (Extension and Outreach Objective) for harvest management and machinery sizing lessons.
- **Module 4. Storage Management**
  - ✓ We will continue module development activities with Amy Kohmetscher.
- **Module 5. Integrating Bioenergy Production into Current Systems**
  - ✓ We will continue module development activities with Amy Kohmetscher.
- **Module 6. Balancing Energy Demand with Food, Feed and Fiber Needs**
  - ✓ We will continue module development activities with Amy Kohmetscher.

2. Actual Accomplishments – Curriculum Development

- **Module 3. Perennial Grass Harvest Management** (Lead authors Pat Murphy and Iman Beheshti Tabar)

  Status of components:

  - ✓ We have completed the internal review of mower/conditioning lessons and made the necessary revisions.

✓ We have submitted the windrowing lessons for internal review.

- **Module 4. Storage Management** (Lead authors Patrick Murphy and Iman Beheshti)

  Status of components:

  ✓ We continued module development activities with Amy Kohmetscher

- **Module 5. Integrating Bioenergy Production into Current Systems** (Lead author Nicole Olynk Widmar)

  Status of components:

  ✓ We completed module development activities with Amy Kohmetscher and module is ready for internal review.

  ✓ We separated budgeting information into a single module with content from Widmar and Alexander.

- **Module 6. Balancing Energy Demand with Food, Feed and Fiber Needs** (Lead author Nicole Olynk Widmar)

  Status of components:

  ✓ We recorded Camtasia lectures from PowerPoint slides.

  ✓ We continued module development activities with Amy Kohmetscher.

3. Explanation of Variance

The reviews of draft lessons for Module 3 by internal project review are being completed, but at a slower pace than anticipated. This will not impact the completion of the subtask activities.

4. Plans for Next Quarter

- **Module 3. Harvesting Systems for Bioenergy Grasses**

  ✓ We will complete internal review of windrowing and baling lessons.

  ✓ We will the submit mower conditioning lesson for publication.

  ✓ We will make content for first three lessons available on E-Library page.

- **Module 4. Storage Systems for Bioenergy Grasses** (Lead authors Pat Murphy and Iman Beheshti Tabar)

Status of components:

- ✓ We will continue module development activities with Amy Kohmetscher.

- **Module 5. Integrating Bioenergy Production into Current Systems**

  - ✓ We will complete internal review and make any necessary corrections/revisions.

- **Module 6. Balancing Energy Demand with Food, Feed and Fiber Needs**

  - ✓ We will complete module development activities with Amy Kohmetscher and submit the module for internal review.

- **Evaluation tasks**

  - ✓ Build quiz functions in Moodle for existing on line module lessons.
  - ✓ Capture responses for program and lesson evaluation for lessons being evaluated fall semester.
  - ✓ Complete evaluation data set for Module 3 to Gwen from fall 2012 offering of ASM 222 at Purdue
  - ✓ Use and evaluate establishment module in John Guretzky's class at UNL (develop quiz questions)

- **Publications, Presentations, and Proposals Submitted**

None to report this period.

Subtask 2A: Training Undergraduates via Internship Program

1. Planned Activities

- We sought to finalize all logistics including the following:

  - ✓ Student travel to Iowa State for the orientation on Wednesday, May 29 – Saturday, June 1, 2013, as well as travel for the students with placements at three partner institutions (University of Minnesota, University of Nebraska, Lincoln, and Idaho National Labs); 2) housing for students placed at Iowa State University as well as the partner institutions; 3) orientation events and speakers (safety training, ethics seminar with case studies, and lab tours) all scheduled; 4) and administration of stipend payments and cash advance provided during orientation.

✓ Provide mentor training using a 15-minute video (created by Objective Co-Project Director Raj Raman). We decided to share with the internship mentors (faculty/grad student/post doc) in mid-May. The goal was to complement the video by a combined face-to-face (for ISU-based mentors) and virtual (via WebEx for partners) meeting to clarify any questions and concerns.

✓ The program launched on May 28, 2013 with the arrival of the students. We conducted an orientation at Iowa State University from May 29 – June 1, 2013. We sent students to their lab placements (start date on June 3, 2013). We held weekly meetings (June 5 – July 24) with student interns to discuss progress, face-to-face for ISU students and virtual (via WebEx) for partner-placement students.

Table 20. 2013 CenUSA Bioenergy Internship Cohort

Name	Major	Institution	CenUSA Faculty	CenUSA Mentor	Placement
Michelle Apolaro	Ag & Biosystems Engineering	Univ. of Florida	Stuart Birrell	Stuart Birrell	Iowa State
David Carlson	Ag Industries & Marketing	Univ. of Minnesota	Virginia Jin	Nate Mellor	Univ. Nebraska, Lincoln
Carly Dutkiewicz	Environmental Geoscience	DePauw Univ.	Charles Schwab	Chuck Schwab / Mark Hanna	Iowa State
Alexander Haag	Chemical Engineering	Univ. of So. Carolina	Robert Brown	Karl Broer	Iowa State
Nathanael Kilburg	Biology	Iowa State Univ.	Gary Gresham / Doug Karlen	Rachel Emerson	UNL-Idaho
Elizabeth Lowry	Biological Systems Engineering	Kansas State Univ.	Robert Brown	Xianglan Bai	Iowa State
James Mahoney	Environmental Science	UW-Madison	Gary Gresham / Doug Karlen	Amber Hoover	UNL-Idaho
Caitlin Mitchell	Environmental Science	Virginia Tech	David Laird	Rivka Fidel	Iowa State
Jennifer Zehnder	Chemical Engineering	Worcester Polytechnic Institute	Jason Hill	Kimberley Mullins	Univ. of Minnesota

2. Actual Accomplishments

- We finalized all logistics including the following: 1) student travel to Iowa State for the orientation on Wednesday, May 29 – Saturday, June 1, 2013, as well as travel for the students with placements at three partner institutions, (University of Minnesota, University of Nebraska, Lincoln, and Idaho National Labs); 2) housing for students placed at Iowa State University as well as the partner institutions; 3) orientation events and speakers (safety training, ethics seminar with case studies, and lab tours) all scheduled; 4) and administration of stipend payments and cash advance provided during orientation.

- We recorded an updated version of the mentor training video (15-minute video created by Raj Raman) on May 3, 2013. We shared a video link with the internship mentors (faculty/grad student/post doc) on May 7, 2013, giving them ample time to view the video. Followed up with a combined face-to-face (for ISU-based mentors) and virtual (via WebEx for partners) meeting on May 20, 2013, to clarify any questions and concerns in preparation of the students' arrival.

- We launched the program on May 28, 2013, with the arrival of the students. We conducted orientation on Wednesday, May 29 – June 1, 2013, that included an overview and expectations of the program, lab safety training provided by Iowa State University's *Environmental Health & Safety* personnel, lab research documentation training provided by a graduate student, an energy overview lecture by Raj Raman, a half day bioethics seminar by Raj Raman, and lab tours.

- Iowa State University's *Research Institute for Studies in Education* (RISE) administered a pre-program survey to assess students on May 29, 2013. This provided a baseline for program evaluation.

- The ISU-based interns participated in a team-building canoe trip at Big Creek Lake on Saturday, June 1, 2013.

- Students placed at partner institutions (University of Nebraska, Lincoln working with Dr. Virginia Jin and Dr. Rob Mitchell; University of Minnesota working with Dr. Jason Hill; and Idaho National Laboratory working with Dr. Gary Gresham) left Iowa State University on June 2 to begin their host lab placements (June 3 – July 28).

- We scheduled and held weekly meetings (June 5 – July 24) with student interns to discuss progress. The meetings were face-to-face for ISU students and virtual (via WebEx) for partner-placement students.

- During weekly meetings, we mentored students regarding research poster content in preparation for their research poster session at the CenUSA Annual Meeting at Purdue University.

- Interns placed at Iowa State University toured Iowa State's BioCentury Research Farm on June 7 and Lincolnway Energy (an ethanol refinery) on June 14, 2013.

- All CenUSA Bioenergy interns attended a presentation ("Innovations in the Bioeconomy") by Peter Keeling (ISU Bioeconomy Institute) on July 14, 2013 and a presentation by Raj Raman on July 25 on "Applying to and Getting into Graduate School." The presentations were face-to-face for ISU-based students and virtual (via Webex) for partner-placed students.

- We coordinated the return of partner institution placed students to Iowa State University on July 28, 2013. We coordinated the CenUSA Annual Meeting logistics (registration, transportation, accommodations, poster session participation) for the nine undergraduate interns attending the meeting at Purdue.

3. Explanation of Variance

- The program director expelled one student on Day 5 of the program for gross unprofessionalism. The student did not report at the van that was to take her to the UNL site on the morning of Monday June 3, 2013. The director and program coordinator worked with ISU police to search the student's room– hoping she was asleep and fearing worse. The room was empty. Because the student was an adult, a missing persons report could not be filed for 24 hours, but the director and program coordinator worked to contact family members, look at social media pages (where the student had posted at 2 am the prior morning), and locate and view surveillance footage from the dorm showing the student leaving the building with an unknown male at 4:30 AM. Over six hours after missing the van, the student called in to inform the director that she had travelled to UNL on her own, and the director released her from the program.

4. Plans for Next Quarter

- On August 1, 2013, the four students placed at partner institutions (University of Minnesota, University of Nebraska, Lincoln, and the Idaho National Labs) were set to return to Iowa State University from the CenUSA annual meeting at Purdue for the conclusion of the program.
- On August 2, 2013, all CenUSA student interns will participate in the ISU university-wide undergraduate research poster session and reception. This poster session, the culminating event of the CenUSA Bioenergy Internship Program, will include all undergraduate research interns who have participated in summer research internships at Iowa State University. This event will showcase over 100 students.

- All students will complete a post-program survey conducted by Iowa State University's *Research Institute for Studies in Education* (RISE). The purpose of this assessment is to (1) assess the program's activities; (2) evaluate the program's successes and challenges; (3) promote continued interest in the program by alumni after they complete their research experience; and (4) track the career paths of our graduates.
- On August 3, 2013, all student interns depart Iowa State University. We will have finalized and processed all payments related to the internship program.

- We will create a calendar and content outline for the summer 2014 program.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Subtask 2B – Training Graduate Students via Intensive Program

1. Planned Activities

- Finalize the list of intensive program attendees.
- Gather final presentation titles and field experience description and details from faculty presenters.
- Request final exam questions from each of the objective areas.
- Finalize all logistics (travel, Iowa State accommodations for graduate student attendees and non-ISU faculty presenters, opening reception, poster session and closing awards luncheon).
- Launch the Intensive Program at Iowa State University with an opening dinner, poster session and reception on Sunday, June 9. Program runs from Monday June 10 – Tuesday, June 18, 2013.

2. Actual Accomplishments

- We finalized the list of intensive program attendees.
- We gathered the final presentation titles and field experience description and details from faculty presenters.
- We requested final exam questions from each of the objective areas.
- We finalized all logistics (travel, Iowa State University accommodations for graduate student attendees and non-ISU faculty presenters, opening reception, poster session and closing awards luncheon).

Table 21. 2013 CenUSA Graduate Students via Intensive Program

	Home Institution	**Major Professor**
Belinda Befort	Univ. of Minnesota	Jason Hill
Iman Beheshti	Purdue Univ.	Patrick Murphy
Curtis Fielder	Iowa State Univ.	Chuck Schwab
Christine Forland	Univ. of Minnesota	Jason Hill
Michael Hudak	Iowa State Univ.	Keri Jacobs
Matt Kararo	Purdue Univ.	Kathryn Orvis
Ambika Karkee	Iowa State Univ.	Stuart Birrell
Brian Krohn	Univ. of Minnesota	Jason Hill

Mike Lawrinenko	Iowa State Univ.	David Laird
Kimberlery Mullins	Univ. of Minnesota	Jason Hill
Tom Nickerson	Univ. of Minnesota	Jason Hill
Ryan Noe	Univ. of Minnesota	Jason Hill
Guillaume Ramstein	Univ. of Wisconsin, Madison	Casler
Emily Rude	Univ. of Wisconsin, Madison	Casler
Anne Sawyer	Univ. of Minnesota	John Lamb & Carl Rosen
Catherine Stewart	Univ. of Nebraska, Lincoln	Gary Yuen
Augusto Souza	Iowa State Univ.	Stuart Birrell
Emily Tissier	Univ. of Minnesota	Jason Hill
Chamila (Rajeeva) Thilakaratne	Iowa State Univ.	Robert Brown
Beverly Wang	Univ. of Minnesota	Jason Hill

- We delivered the Intensive Program with lectures, recitations, field experiences as follows:

✓ **Sunday, June 9, 2013**

- Participants arrived at Iowa State in the afternoon.
- 6:00 PM: Welcome Dinner and Overview of Program.
- 7:00 PM – 8:00 PM: Grad Student Research Poster Session.

✓ **Monday, June 10, 2013**

- 9:00 AM – 11:30 AM: Objective 1. Feedstock Development lecture and recitation by Ken Vogel.
- 1:00 PM – 4:00 PM: field tours at the ISU Agronomy Farm led by Ken Moore and Ken Vogel.

✓ **Tuesday, June 11, 2013**

- 9:00 AM – 11:30 AM: Objective 2. Field Level Sustainability lecture by Rob Mitchell.
- 1:00 PM – 4:30 PM: Biochar field tour led by David Laird and Doug Karlen.

- ✓ **Wednesday, June 12, 2013**
  - 9:00 AM – 11:30 AM: Seminar – Responsible Conduct of Research by Dr. Clark Wolf, ISU Center for Bioethics, and Raj Raman.
  - 1:00 PM – 4:00 PM: Objective 3. Feedstock Logistics lecture followed by BioCentury Research Farm tour by Stuart Birrell.
- ✓ **Thursday, June 13, 2013**
  - 9:00 AM – 11:30 AM: Objective 5. Feedstock Conversion/Refining lecture by Robert Brown.
  - 1:00 PM – 4:00 PM: Lab experience at the Biorenewables Research Lab led by Robert Brown and staff.
- ✓ **Friday, June 14, 2013**
  - 8:00 AM – 10:00 AM: Objective 7. Health and Safety lecture by Mark Hanna
  - 10:15 AM – 12:00 PM: Objective 9. Extension and Outreach lecture/visioning exercise led by Jill Euken
  - 1:30 PM – 3:00 PM: CenUSA Bioenergy Advisory Board Panel Session moderated by Raj Raman.
- ✓ **Saturday, June 15, 2013**
  - 9:00 AM – 12:00 PM: Teams of 5-8 grad students discuss challenges presented by the Industrial Advisory Board
  - 1:00 PM – 3:00 PM: Teams report on response to challenges to Ken Moore, Raj Raman, and Patrick Murphy
- ✓ **Sunday, June 16, 2013**
  - Free Day – Recreation Option – a guided Boone River (Iowa) canoeing trip.
- ✓ **Monday, June 17, 2013**
  - 9:00 AM – 11:30 AM: Objective 4. System Performance lecture by Jason Hill.
  - 1:00 PM – 3:30 PM: Objective 6: Markets and Distribution lecture by Dermot Hayes.

Photo 7. Summer 2013 CenUSA training Graduate Students via Intensive Program

- ✓ **Tuesday, June 18, 2013**
    - 9:00 AM – 12:00 PM: Final Exam.
    - 12:00 – 1:00 PM: Awards Luncheon.
    - 1:00 PM: Participants departed Iowa State University.

- We mailed program certificates to all attendees who completed the final examination. An exam score of 70-90 percent earned a certificate of completion; a score of 90-100 percent earned a certificate of completion with honors.

- We processed all participant travel reimbursements.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

Not applicable.

5. Publications, Presentations, and Proposals Submitted

Photo 7. Summer 2013 CenUSA Training Graduate Students via Intensive Program

None to report this period.

Report for Subtask 2C – Training Graduate Students Via Monthly Research Webinar

1. Planned Activities

- Considering the heavy load we have with educational programming (10 undergraduate research interns, and the delivery of the graduate Intensive Program on June 9-18), we will restart the CenUSA research seminars at the monthly co-project director meeting scheduled for August 30, 2013.

- Since we have completed seminars on Objectives 1-3, we will pick up in August with Objective 4.

- Begin organization of next three webinars (Objectives 4-6) to be delivered August – October 2013.

2. Actual Accomplishments

- It was decided to restart the seminar series directly following the monthly co-project director meeting on September 27, 2013.

- With the completion of seminars focusing on Objectives 1-3, we will focus on Objective 4 for the September 27, 2013, research seminar.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Organize the next three research webinars:
  - ✓ Objective 4 – September 27, 2013.
  - ✓ Objective 5 – October 25, 2013.
  - ✓ Objective 6 – November 22, 2013.

5. Publications / Presentations/Proposals Submitted.

None this period.

Objective 9 Extension and Outreach

The Extension and Outreach objective serves as CenUSA's link to the larger community of agricultural and horticultural producers and to the public-at-large. CenUSA's Extension objective focuses on four primary goals:

- Developing awareness of biochar and bioenergy materials for extension educators, industry leaders, farmers and the general public.
- Increasing knowledge and awareness of the benefits of perennial and biochar agriculture and horticulture.
- Establishing and utilizing a "citizen science" program to share "Best Management Practices" for perennial grass and biochar agriculture and the horticulture industry.
- Stimulating adoption of perennial grass production, pyrolytic conversion of biomass to biofuels, and utilization of biochar as a soil amendment by Agricultural producers and Extension personnel.

The following teams conduct the Outreach and Extension Objective's work.

- **Extension Staff Training/eXtension Team**

  This team concentrates on creating and promoting professional development activities for Extension educators and agricultural and horticultural industry leaders.

- **Producer Research Plots/Perennial Grass Team**

  This team covers the areas of:

  - Production, harvest, storage, transportation.
  - Social and community impacts.
  - Producer and general public awareness of perennial crops and Biochar agriculture.
  - Certified Crop Advisor training.

- **Economics and Decision Tools Team**

  This team will focus on the development of crop enterprise decision support tools to analyze the economic possibilities associated with converting acreage from existing conventional crops to energy biomass feedstock crops.

- **Health and Safety Team**
  This team integrates its work with the Producer Research Plots/Perennial Grass and the Public Awareness/Horticulture/eXtension 4-H and Youth teams (Objective 7).

- **Public Awareness/Horticulture/eXtension 4-H and Youth Team**

  This team focuses on two separate areas:

  - **Youth Development** – The emphasis is on developing a series of experiential programs for youth that introduce the topics of biofuels production, carbon and nutrient cycling.

  - **Broader Public Education/Master Gardener Program** – The goal is to acquaint the non-farm community with biofuels and biochar through a series of outreach activities using the highly successful Master Gardener volunteer model as the means of introducing the topics to the public.

  - **Evaluation/Administration Team** –This team coordinates CenUSA's extensive extension and outreach activities. The team is also charged with developing evaluation mechanisms for assessing learning and behavior change resulting from extension and outreach activities, compiling evaluation results and preparing reports, and coordination of team meetings.

- **Extension Staff Training/eXtension Team**

  1. **Planned Activities**

     - Two webinars.

     - Gather footage for at least one video (entomology, plant pathology).

     - Continue work on fact sheets and eXtension articles.

  2. **Actual Accomplishments**

     - Webinar June 28, 2013, "Discovery of Aphid Resistance in Perennial Bioenergy Feedstock" Kyle Koch, Graduate Student at University of Nebraska
     - Webinar July 10th, "An Overview of Switchgrass Diseases" by Professor Stephen Wegulo, University of Nebraska

     - Footage gathered for entomology video and plant pathology video

     - Continuing impact of archived videos on Vimeo channel; during this quarter, the 23 CenUSA archived videos:

       ✓ 94 plays.

       ✓ 5,300 loads; 2,734 of those loads came from our videos embedded on other sites.

       ✓ Vimeo videos were downloaded 53 times (this means the video was saved to their hard drive; users do this because they have limited internet connectivity which does no allow for live streaming of a video). Once the video is downloaded, it is available on their computer to watch at their convenience.

- ✓ CenUSA videos are also posted on YouTube, and those videos have been downloaded 3,249 times as of August 22, 2013. This is total views since videos were posted, not necessarily just for this quarter.

- Progress was made in the review, editing, and posting of the following eXtension articles/fact sheets:

  - ✓ Plant Breeders Create New and Better Switchgrass Varieties for Biofuels.
  - ✓ Research Finds Strong Genetic Diversity in Switchgrass Gene Pools.
  - ✓ Storing Harvested Perennial Grass Grown for Biofuel.
  - ✓ Switchgrass Stand Establishment: Key Factors.
  - ✓ Control Weeds in Switchgrass (Panicum Virgatum L.) Grown for Biomass.
  - ✓ How to Successfully Harvest Switchgrass Grown for Biofuel.
  - ✓ Establishing and Managing Perennial Grass Energy Crop Demonstration Plots.

3. Plans for Next Quarter

- At least one webinar (economics topic).
- Finish entomology video.
- Continue work on fact sheets/eXtension articles.

4. Publications, Presentations, Proposals Submitted

- eXtension articles listed above are in various stages of the review and publication process. All of them will be submitted for publication upon completing the eXtension review process.
- CenUSA Extension team members Chad Martin and John Hay gave two presentations at the National Extension Energy Conference in Fort Collins, Colorado.

5. Explanation of Variance

Not applicable. No variance to report.

6. Plans for Next Quarter

- We will complete at least one webinar (economics topic).
- We will finish the entomology video.
- We will continue work on fact sheets/eXtension articles.

7. Publications, Presentations, and Proposals Submitted

See above.

Producer Research Plots/Perennial Grass Team

1. Planned Activities

- **Indiana, Iowa, Minnesota, Nebraska**
  - ✓ Monitor producer plots in each state that were established in 2012, address establishment and weed control issues;
  - ✓ Establish new set of producer plots in each state

2. Actual Accomplishments

Total number of participants in plot-related programming this quarter was 135 individual (96 males, 39 females; 2 Hispanics, 125 whites, 3 African-American, 5 Asian).

- **Indiana**
  - ✓ We maintained the plot established on the *Jerry Sweeten Farm* in 2012,and established new plots at the *Larry Pflug Farm* and at the Indiana FFA Leadership Center.
  - ✓ We hosted a Field Day at the *Jerry Sweeten Farm* on June 21, 2013.
  - ✓ We presented at the 4-H Energy Academy and the Purdue Energy Academy.
- **Iowa**
  - ✓ We evaluated seedings at the *Phil Winborn* Plots, reseeding as needed in five of six plots.

Photo 8. Seeding new plots at the Pflug Farms demonstration plot planting on reclaimed coal mined ground, Oakland City, Indiana.

- ✓ On May 21, 2013 we seeded new switchgrass plots at the *SE Research and Demonstration Farm*.
- ✓ On May 24, 2013 we applied herbicide to switchgrass plots at the *SE Research and Demonstration Farm.*
- ✓ On June 4, 2013 we reseeded five of six plots at the *Phil Winborn* Plots and applied herbicides.
- ✓ On June 11, 2013 we applied atrazine to the *Phil Winborn* Plots.
- ✓ On July 3, 2013 we applied 2,4-D to the *Phil Winborn* Plots.
- ✓ On July 25, 2013 we applied 2,4-D to plots at the *SE Research and Demonstration Farm.*

- **Minnesota**

  - ✓ The Elko site established in 2012 is mostly covered with switchgrass; small parts of the sloped areas will need to be reseeded in 2014, due to heavy rains in the spring of 2013.

- ✓ We attempted to establish an additional demo site at Lamberton, Minnesota. Due to heavy rain after seeding, the seed was buried and germination was poor. The site will need to be replanted next year.

- **Nebraska**

  - ✓ We collected biomass and visual observation measurements in June and July, 2013 at the *Humboldt Farm*.
  - ✓ We developed storyboards for field plot tour groups.
  - ✓ CenUSA presentations were prepared for the LEAD alumni bus tour at the Humboldt site.
  - ✓ We installed automated weather stations at both Nebraska sites.
  - ✓ We controlled large broadleaf weeds at both sites.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

- **Indiana**

  - ✓ A CenUSA Harvest Demonstration has been scheduled for October 15, 2013.
  - ✓ We held the *CenUSA Stand Establishment Success of Warm-Season Grasses at Purdue Forage Management Day* at the Diagnostic Training and Research Center on September 4, 2013.
  - ✓ We had a CenUSA exhibit at the National Association of Community Development Extension Professionals' Galaxy Conference in Pittsburg Pennsylvania, September 17-19, 2013.
  - ✓ We conducted lot maintenance activities at all sites, and data collection at the *Sweeten Farm* Plot.
  - ✓ We presented at the Purdue Extension Annual Professional Development Conference Break-out Session.
  - ✓ We attended the Food, Fuel, and Fiber Extension Professional Development meeting in Champaign, Illinois.

- **Nebraska**

- ✓ We collected biomass samples at the Humboldt site.
- ✓ We collected visual obstruction measurements at the Humboldt site.
- ✓ We secured a local farm operator to remove biomass at the end of the year from the Humboldt site.
- ✓ We mowed large escaped broadleaf weeds at the Milford site.

- **Iowa**
  - ✓ We conducted a Field Day at the Demonstration plots at the *SE Research and Demonstration Farm* on September 9, 2013.
- **Minnesota**
  - ✓ We harvested demo plots at the Elko site. We continued our weed control measures.

5. **Publications, Presentations, and Proposals Submitted**

- Presentation at National Extension Energy Conference in Fort Collins, Colorado.
- CenUSA Annual Meeting Report of Extension Activities hosted at Purdue University.
- Presentations at field days and camps.
- Fact Sheets, Guides and Articles – see list in eXtension section above.
- Research Summaries – see list in eXtension section above.

Economics and Decision Tools Team

1. **Planned Activities**

Continue development and refinement of the NBMP watershed nitrogen reduction planning tool.

2. **Actual Accomplishments**

Continued development and refinement of the NBMP watershed nitrogen reduction planning tool.

3. **Explanation of Variance**

No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**

   Present the tool to an interagency group of experts and discuss the feasibility of various N reduction milestones (August 19, 2013). Make other presentations as needed, especially to stakeholder groups.

5. **Publications, Presentations, and Proposals Submitted**

   None to report this period.

Health and Safety Team

1. **Planned Activities**

   See Objective 7, above.

2. **Actual Accomplishments**
   See Objective 7, above.

3. **Explanation of Variance**

   No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**

   See Objective 7, above.

5. **Publications, Presentations, and Proposals Submitted**

   None.

Public Awareness/Horticulture/eXtension 4-H and Youth Team

3.A – Youth Development

1. **Planned Activities (Youth Development)**

   - **Indiana**

     ✓ Complete the 4-H Science Renewable Energy Workshop.

     ✓ Continue expansion of online modules and lesson plans.

     ✓ Develop the working outline for 4-H curriculum and school-based activities.

- ✓ Finish biofuel fact sheets.
- ✓ Evaluate data from 4-H Science Workshop.

- **Iowa**

- ✓ Develop a "C6" iPad app (learning materials about "old" fossil carbon and "new" renewable carbon). See Figure 13.
- ✓ Give a Presentation for Iowa youth and volunteers at Iowa 4-H Youth Conference in June 2013.

2. Actual Accomplishments (Youth Development)

- **Indiana**

- ✓ We held 4-H Science Workshop June 12-14 for 10 high school 4-H members. Participants showed increased knowledge of biochar, pyrolysis and 2nd generation biofuels in pre/post surveys; career interests in STEM remained relatively stable (high) in pre/post surveys.
- ✓ We held a *4-H Outreach Round-up* June 24-28, 2013 for 14 4-H youth; participants learned about wind, biomass and solar energy and showed increases in knowledge as measured by pre/post surveys.
- ✓ We held the *Indiana Hoosier Agribusiness Science Academy Summer Institute* for 12 inner-city youth interested in post-secondary study. Students participated in two 3-hour renewable energy sessions and showed increases in knowledge and interest in STEM careers.
- ✓ We completed an outline for 4-H curriculum and school-based lessons.
- ✓ We completed additional work on the online modules and lesson plans.
- ✓ Two undergraduate agricultural education students were hired for the summer to work on the 4-H curriculum, school-based lessons, and online modules.

- **Iowa**

- ✓ Developed C6 iPad app and exhibit materials for use at the 2013 Iowa State Fair.
- ✓ Presentation to youth and volunteers at the Iowa 4-H Youth Conference on June: 8 adult participants, 6 male/2 female, all white; 10 youth participants, 4 male and 6 female, all white.

Figure 13. C6 iPad App character

3. **Explanation of Variance (Youth Development)**

- **Indiana**

  Project fact sheets need to go through the College of Agriculture Ag Communications editing process.

4. **Plans for Next Quarter (Youth Development)**

- **Indiana**

  ✓ Provide renewable energy information through a CenUSA display at the 2013 Indiana State Fair.

  ✓ Create a career component for the static CenUSA display.

  ✓ Utilize the CenUSA display at 4-H/FFA state level events in September, October, and December 2013.

  ✓ Complete the editing process for project fact sheets.

- ✓ Edit the first drafts of the 4-H curriculum and school-based lessons.
- ✓ Continue building online lessons.
- ✓ Collaborate with Keith Johnson and Chad Martin on FFA students co-managing switchgrass demonstration plots at the Indiana FFA Center.
- ✓ Determine the possibility of expansion of youth co-management of additional demonstration plots at other FFA locations around the state.
- ✓ Acquire licensing and purchase software to host on-line modules.
- ✓ Presentation planned at State 4-H Staff Annual Meeting.
- ✓ Provide training for planned school garden programming – elementary and high school.
- ✓ Plan and implement school garden program. This is expected to carry over to the next quarter as well.

- **Iowa**

  - ✓ Roll out C6 materials and exhibit at the 2013 Iowa State Fair.
  - ✓ Collect data regarding learning about carbon at the Iowa State Fair.
  - ✓ Continue development of the C6 App and curriculum. Conduct workshops for Iowa teachers and county youth staff.

5. **Publications, Presentations, and Proposals Submitted (Youth Development)**

Iowa's C6 App and curriculum.

3.B – Broader Public education/Master Gardener Program

1. **Planned Activities (Broader Public Education/Master Gardener Program)**

- **Iowa**

  - ✓ Compile Master Gardener data collection training information.
  - ✓ Continue recruiting Master Gardener volunteers.
  - ✓ Send plant and seeds to three Iowa sites for planting.

- ✓ Hold garden planting sessions at each of the three test sites with Master Gardener volunteers to plant the biochar plots.
- ✓ Hold Master Gardener training meetings on data collection at each of the three test Iowa sites. Work with farm superintendents to also attend these meetings.
- ✓ Hold Master Gardener Summer Session Field Day (includes biochar test plots).
- ✓ Hold Home Demonstration Garden Field Days at three sites (includes biochar test plots).

- **Minnesota**

  - ✓ Conduct soil tests for each Minnesota site.
  - ✓ Meet with Iowa Master Gardener team in Clear Lake Iowa on May 6, 2013 to discuss upcoming season and consistent participant surveys.
  - ✓ Host local Extension Master Gardener site leader meeting on May 15, 2013.
  - ✓ Develop a new biochar teaching garden in conjunction with Master Gardeners and members of the Fond du Lac Tribal Community in northern Minnesota near Cloquet.

Photo 9. Volunteers carry plants and planting supplies from cars to garden (May 29, 2013)

Photo 10. The sandy soils at the Fond du Lac Tribal Community site are not easy to work with (May 29, 2013).

- ✓ Prepare and plant the year-two demonstration gardens at the Minnesota Landscape Arboretum, the University of Minnesota-St Paul campus and the Bunker Hills site in Andover, Minnesota.
- ✓ Host a webinar *Biochar: What is it?* for Master Gardener volunteers.
- ✓ Develop an evaluation tool for participants who participate in webinar.
- ✓ Coordinate the CenUSA Extension team phone meeting on June 3, 2013.
- ✓ Maintain all demonstration gardens.
- ✓ Blog about garden establishment and progress.
- ✓ Prepare biochar exhibits for local county fairs and events including the Minnesota State Fair.
- ✓ Collect data on select plants in the gardens in May, June and July 2013.
- ✓ Develop interpretative signage at all Iowa and Minnesota sites.

2. Actual Accomplishments (Broader Public Education/Master Gardener Program)

- **Iowa**

  ✓ We had 350 (141 males and 209 females) total participants this quarter.

  ✓ We planted biochar test gardens in between showers. The rainy weather created a much later than expected planting date for each of the three Iowa sites in 2013 (Armstrong Farm = June 2; Muscatine = June 4; Hort Station = June 14).

  ✓ We hosted a Master Gardener Summer Session Field Day at the Horticultural Station near Gilbert, Iowa on July 13, 2013. 40 Master Gardeners from across Iowa were in attendance. Surveys were completed and will be compiled with surveys received from three additional Field Day events to be held for the public in August 2013.

  ✓ We held Master Gardener training meetings on proper data collection and expectations on July 25, 2013 for 8 Master Gardener volunteers at the Armstrong Farm and on July 26, 2013 for five Master Gardener volunteers at the Horticultural Station near Gilbert, Iowa.

Photo 11. Iowa Master Gardener's admiring their biochar test plots at the Horticulture Research Station near Ames, IA.

- **Minnesota**

- ✓ We had 246 participants this quarter.
- ✓ Soil tests were conducted at all four garden sites and each site was amended with fertilizer based on soil test recommendations.
- ✓ The Iowa and Minnesota CenUSA Extension teams met in Clear Lake to discuss processes for the upcoming season.

- Local Extension Master Gardener site leaders met in May to develop strategies for coordinating volunteers who work on the project. An operating procedural manual was developed for Master Gardener Volunteers.

- We prepared and planted a new biochar teaching garden at the Fond du Lac Tribal Community Center near Cloquet Minnesota. Approximately 25 adults and children participated.

Photo 12. Minnesota Master Gardener Planting Day, May 22, 2013.

- Approximately 30 Master Gardener volunteers planted three biochar demonstration gardens for Project Year 2 at the Minnesota Landscape Arboretum, the University of Minnesota, St. Paul Campus, the Bunker Hills site and Andover locations.

- Nineteen Master Gardener volunteers participated in the webinar "Biochar: What is it?"

- Nineteen Master Gardener volunteers completed the evaluation of the webinar.

- We coordinated the CenUSA Extension team phone meeting on June 3, 2013.

- All demonstration gardens are being maintained on a weekly basis.

- Two blogs were published: The first was about the planting day at the new site at the Fond du Lac Tribal Community Center (http://blogs.extension.org/mastergardener/2013/06/26/planting-day-at-the-fond-du-lac-biochar-demonstration-garden/. The second was about the establishment of the gardens in the Twin Cities (http://blogs.extension.org/mastergardener/2013/07/30/cenusa-extension-master-gardener-biochar-demonstration-gardens-the-beginning-of-year-two/).

- Biochar exhibits were updated to reflect the new site; flyers were printed and new evaluation postcards were developed for each event. The biochar exhibit was displayed at the 2013 Anoka County Fair at the Extension Master Gardener information booth.
- The three team members who work directly with the Master Gardeners in Minnesota attended the CenUSA annual meeting in West Lafayette, Indiana.

- Master Gardener volunteers have been collecting data on various crops that include plant heights, widths, and color, along with yields, and including count and weight. Data collection will continue on various crops through the first frost.

- Draft signage has been developed for the interpretive signage and is nearing completion.

3. Explanation of Variance (Broader Public Education/Master Gardener Program)

- **Iowa**

  ✓ Master Gardener garden planting sessions were not held due to weather (the rainy conditions forced all three of the research farm superintendents to plant the test plots "between showers" at short notice, so Master Gardeners could to be notified in advance to attend).

  ✓ Data on "race/ethnicity" was not collected from survey respondents.

4. Plans for Next Quarter (Broader Public Education/Master Gardener Program)

- **Iowa**

  ✓ We will continue to record crop data from test plots.

  ✓ We will create an on-line video with Amy Kohmetscher from UNL to educate Master Gardeners across the state on the Biochar project.

- **Minnesota**

  ✓ Continue to collect data at the gardens until frost.

  ✓ Complete the final design for the interpretive signage.

  ✓ Display the biochar exhibit at the Northern Threshing show, the Minnesota State Fair and the Fond du Lac Tribal Community Center at the Carlton County Fair.

  ✓ Provide post-frost fall cleanup at the garden sites.

5. **Publications, Presentations, and Proposals Submitted (Broader Public Education/Master Gardener Program)**

- eXtension blogs (see links above).
- Update Master Gardener Volunteer tool *Data Collection Instructions and 2013 Harvest Dates – Biochar Project*. (See Exhibit 12. Extension Master Gardeners - Data Collection Instructions and 2013 Harvest Dates CenUSA Biochar Project).

Evaluation/Administration Team

1. **Planned Activities**

- Collect information from all Extension Team members for reporting at CenUSA Annual meeting.
- Develop a presentation for annual meeting.
- Plan and facilitate Extension team meeting during the 2013 Annual Meeting.
- Organize planning meetings for CenUSA-Hypoxia Task Force joint conference; coordinate marketing for the conference; assist Jason Hill in identifying and recruiting speakers and participants for the conference.
- Participate in Extension team meetings and provide advice as needed.
- Develop, implement and assess evaluation tools.
- Assist CenUSA colleagues in developing and administering appropriate evaluation tools.
- Prepare exhibit and presentation re: CenUSA for Extension Galaxy conference.

2. **Actual Accomplishments**

- Collected information, prepared and delivered Extension presentation for CenUSA Annual meeting.

- Facilitated Extension team meeting at 2013 CenUSA Annual Meeting.

- Scheduled, planned and facilitated 6 meetings for CenUSA-Hypoxia Task Force conference to be held in Minneapolis, September 23-24, 2013.

- Participated in Extension team meetings as needed.

- Prepared exhibit and handout materials for CenUSA presence at Galaxy conference in September 2013.

- Collaborated to develop a standardized webinar evaluation.

- Assessed survey results for Indiana Grass Field Day, Indiana Small Farms Conference.
- Wrote report on survey results for webinar *Thermochemical Conversion of Biomass to Drop-In Biofuels*.

- Wrote report on *Drivers and Barriers to Perennial Grass Production for Biofuels.*

- Developed 'business reply' postcards to capture feedback from participants at field days where survey instruments are not feasible.

- Prepared and delivered Extension and Evaluation presentation to CenUSA graduate students in the 2013 Intensive Program.

- Introduced concept of "Collective Impact" as annual meeting to encourage CenUSA participants to begin thinking in terms of overall impact for the project.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

- Host CenUSA-Hypoxia Task Force conference (September 23-24, 2013).

- Exhibit and present at Galaxy conference (September 17-19, 2013).

- Present the tool to an interagency group of experts and discuss the feasibility of various N reduction milestones (August 19, 2013). Make other presentations as needed, especially to stakeholder groups.

5. **Publications, Presentations, and Proposals Submitted**
   - Drivers and Barriers to Perennial Grass Production for Biofuels" (See Exhibit 11).
   - "Increasing Knowledge about Producing Biomass" (See Exhibit 12. Increasing Knowledge About Producing Biomass).

Exhibit 1

Iowa State University - AFRI-CAP
Objective 1 (Revised)

Objective 1 - Feedstock Development	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Task 1 - breeding and evaluation trials establishment.		x	x																	
Task 2 - stands, harvesting, sampling																				
Task 3 - Selections made for crossing																				
Crossing and seed production																				
Cultivar and germplasm releases																				
	The project started on August 1, 2011. The first quarter of Year 1 is August thru Dec., 2011. Quarter 2 for the period 2011-2012 is Jan thru March , 2012.																			
	Green bars are the first set of selection nurseries and yield trials. Yellow bars are the 2nd set of yield trials and selection nurseries.																			
	See Tables 1 and 2 of Feedstock Section for specific details																			

Metrics: Major Products & Deliverables

Year 3

1. Adaption & production data on all available strains
2. Composition and pyrolsis data on feedstocks
3. Initial NIRS calibrations for pyrolysis products.
4. Plant disease and insect resistance data on tested lines.

Year 4

1. Best experimental strains identified for release.
2. Completion of first selection cycle. Data on genetic variation on composition & pyrolysis products.

Year 5

1. Switchgrass, big bluestem indiangrass cultivar releases
2. Experimental strains developed for 2nd testing cycle.
3. Fully validated NIRS calibrations for pyrolyis.
4. Advanced selection criteria developed utilizing molecular marker and pyrolsis related traits.

CenUSA Objective 1 Timelines/Deliverables

Feedstock development: Specific milestones and objectives are given in the appendix time line and is the response to Specific Technical Question 2. In brief, two cultivars each of switchgrass, big bluestem, and indiangrass will be released in five years and six to 12 experimental strains will be developed for a second cycle of regional field trials. A detailed summary is listed below.

Risks and mitigation: The two primary factors that could affect the completion of milestones and objectives during the five year period are the stability and continuity of USDA funds and weather. Funding issues will simply have to be jointly addressed by NIFA and project managers as they occur. It may be necessary to delay or repeat some work, such as establishment of breeding nurseries or field trials, if weather conditions result in stand failures. This would delay reaching milestones but milestones and objectives could still be met.

Metrics: Major Products & Deliverables

Year 3

1. Adaption & production data on all available strains
2. Composition and pyrolsis data on feedstocks
3. Initial NIRS calibrations for pyrolysis products.
4. Plant disease and insect resistance data on tested lines.

Year 4

1. Best experimental strains identified for release.
2. Completion of first selection cycle. Data on genetic variation on composition & pyrolysis products.

Year 5

1. Switchgrass, big bluestem indiangrass cultivar releases
2. Experimental strains developed for 2nd testing cycle.
3. Fully validated NIRS calibrations for pyrolyis.
4. Advanced selection criteria developed utilizing molecular marker and pyrolsis related traits.

Research phases and timetable for a perennial forage breeding program.

Phase	Year 1	Year 2	Year 3	Year 4	Year 5
Phase 1: Germplasm acquisition & evaluation	Establish germplasm evaluation nurseries.	Evaluate forage yields, quality, and other traits	2nd year of evaluation	Identify superior plants and move to crossing blocks, initial seed harvest	Harvest seed. Use seed in Phase 2. Synthetic populations may need to be random mated several generations.
Phase 2: Recurrent selection breeding program.	Establish selection nurseries using seed from selected germplasm sources.	Evaluate forage yields, quality, and other traits	2nd year of evaluation	Identify superior plants and move to crossing blocks, initial seed harvest	Harvest seed, repeat cycle in breeding program. Use seed to plant regional trials.
Phase 3: Regional small plot trials	Plant trials	Harvest trials	Harvest trials	Summarize data, begin seed increase of best strains for pasture trials or field scale trials.	Seed harvested from increase nurseries
Phase 4: Field scale or grazing trials of advanced lines	Plant field or pastures trials.	Field or grazing trial production harvests.	Field or grazing trial production scale harvests.	Increase best strain for release. Continue to monitor trials.	Release seed to seed growers

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OBJECTIVE 2

(Revised 11.11.11)

	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
Objective 2 - Sustainable Production	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Task 1 - Identify sites, complete initial soil profile sampling (1.2 m depth) and establish experimental plots for both biomass production and biochar plot studies																				
Task 2 - Annual plot management, GHG flux monitoring, surface soil (0-15 cm depth) sampling, harvest and biomass sampling																				
Task 3 - Plot management, GHG flux monitoring, surface soil profile (1.2 m depth) sampling, harvest and biomass sampling																				
Task 4 - Data compilation, statistical analysis, report writing, and data archiving																				

Metrics: Major Products & Deliverables

Year 1

1. Baseline soil profile data for all plots
2. Stand establishment data and management report

Year 2-5

1. Annual reports of data for GHG emissions, biomass production, surface soil, and management.

Year 5

1. New best management practices for switchgrass in the region based on accumulated data.
2. Best management practices for multi-species mixtures in the region.
3. Comprehensive productivity, C, GHG, and other data for use by team economists and modelers.
4. Baseline data on 4 year impact of biochar
5. Archived data for long term l use

Iowa State University - AFRI-CAP

OBJECTIVE 3

Objective 3 - Feedstock Logistics	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Task 1																				
Producer level logistic costing evaluating the interaction spatial distribution of soil types, land use and threshold																				
Task 2																				
Improve biomass drying rate - investigate desiccation, tedding, and maceration																				
Develop standardized modules of compacted biomass that has been size-reduced at harvest - and compare with INL PDU system.																				
Quantify the storage characteristics of the standardized biomass modules.																				
Develop low energy size-reduction mechanisms - longitudinal-shear/maceration and precision-cut mechanisms.																				
Task 3																				
Supply material to cooperators to evaluate conversion efficiency and biochar quality.																				

Metrics: Major Products & Deliverables

Year 3

1. Intial results on biomass harvesting and storage technologies.
2. initial results on biomass compaction and mechanical field pre-processing.
3. Biomass representing different harvest and field pre-procssing process deliverd for pyrolsis testing.

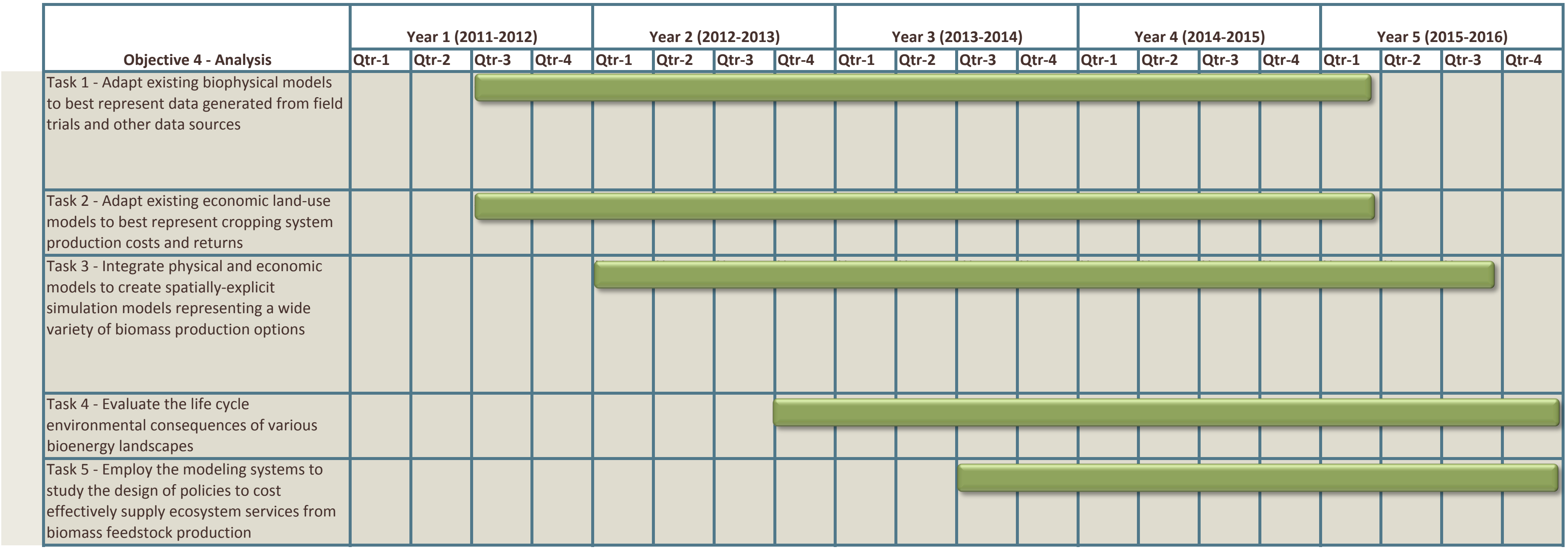
Year 4

1. Initial summary of the storage characteritics of the standardized biomass modules.

Year 5

1. Best harvest management practices for perennial grasses summarized.
2. Best management practices for compaction and field pre-processing developed and validated.
3. In conjunction with conversion objective, effect of harvest and field pre-processing on pyrolsis yields and costs quantified.

Iowa State University - AFRI-CAP
OBJECTIVE 4



Deliverables and Metrics

Year 1

1. Standardize data formats for use across modeling platforms

Year 5

1. Models adapted for evaluating perennial grass based systems
2. Models adapted for evaluating cropping system production costs and returns
3. Models adapted for spatially-explicit simulations
4. Complete life cycle and economic analysis on which policy decisions can be based

Iowa State University - AFRI-CAP (Revised)

OBJECTIVE 5

Objective 5 - Conversion/Refining	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Task 1 - Identify germplasm																				
Task 2 - Perform technoeconomic analysis (TEA)																				
Task 3 - Prepare and characterize biochar																				

Timeline Note: Quarter 1 of Year 1 will cover the start of the project (August 1, 2011) through December 31, 2011. Year 1 will end Sept. 30, 2012. Years 2-5 will begin October 1 and end September 30.

Deliverables and Metrics

Year 2

1. Understanding of how lignin can be used along with carbohydrate for fuel production.

Year 3

1. Understanding of the form and fate of inorganic compounds (alkali and nitrogen) in plant materials.
2. Public and market acceptance of biochar as a soil amendment and carbon sequestration agent

Year 4

1. Analytical methods to support selection of suitable feedstocks.
2. Estimates of environmental impacts of biofuels production; and cost of biofuels for different feedstock production scenarios.

Year 5

1. Biomass feedstocks designed specifically for thermochemical processing.
2. Improved understanding of the interrelationship of feedstock supply and biofuels manufacturing systems.

Iowa State University - AFRI-CAP
OBJECTIVE 6
(Revised 11.11.11)

	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
Objective 6 - Markets and Distribution	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Task 1 - Study and quantify the production- and location-specific barriers and drivers of implementation of the entire system from producers of feedstock, producer groups and their stakeholders, and the biofuel producers																				
Task 2 - Perrin (UNL) will estimate threshold returns that make feasible biomass production for biofuels																				
Task 3 - Jacobs (ISU) with input and expertise from Hayes (ISU) and Perrin (UNL) will develop the set of market, contract and policy mechanisms necessary to make optimal and sustainable the production of biomass feedstock on the identified lands																				
4. Jacobs (ISU) will develop a decision model to predict the likelihood that the targeted land identified within Objective 4 will be used for perennial biomass crop production, accounting for returns to biomass and row crop production, market conditions and policy and contract incentives and mechanisms.																				
5. Hayes (ISU) will use existing national and global agricultural policy simulation models that endogenize prices to estimate scale effects of bio-energy production on national and international commodity markets and greenhouse gas (GHG) emissions on regional and global food, feed, fiber and energy systems both with and without indirect land use impacts using the Food and Agricultural Policy Research Institute (FAPRI) model																				
6. Hayes (ISU), in collaborationwith investigators from Objective 4, will develop an alternative procedure to conduct life cycle analysis that accounts for the opportunity cost of land.																				

Deliverables and Metrics

Year 2

1. Computer model of production-specific and location-specific barriers and drivers of implementing the biofuels value-chain.
2. Computer model that estimates threshold returns on biomass crop production.
3. Decision model for evaluating the likelihood that perennial biomass production will be established in the targeted lands.

Year 3

1. Alternative procedure for to conduct life cycle analysis based on the opportunity cost of land.
2. Estimates of the effects of large-scale biomass production in the targeted region on national and international commodity markets.

Year 4

1. Market, contract and policy mechanism established for calculating optimal and sustainable production of biomass in the targeted region.
2. Estimate yield impacts of biochar application in the targeted region.

Year 5

1. Identification of production-specific and location-specific barriers and drivers associated with implementing the biofuels value-chain in the targeted region.
2. Estimates of threshold returns on biomass crop production in the targeted region. Estimate cost impacts of co-products from fuel production on regional and global food, feed, fiber, and energy markets.
3. Probability distributions of the likelihood that perennial biomass production will be established in the targeted lands.

Iowa State University - AFRI-CAP (POST BUDGET CUT)

OBJECTIVE 7

	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
Objective 7 - Health and Safety	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Task 1 - Managing risks in producing feedstocks																				
Task 2 - Assessing the primary dust exposure																				

Deliverables and Metrics

Year 2

1. Baseline assessment of potential hazards of tasks associated with biomass production that is sufficiently detailed for establishing health and safety standards and educating agricultural producers.
2. Decision tool in health and safety issues related to biomass production to support development of educational modules to be developed as part of Objective 8.

Year 3

1. Baseline assessment of expected worker exposures for identified hazardous aerosols.
2. Refined decision tool in health and safety issues related making recommendations of protective actions to biomass production.

Year 5

1. Analytical pilot data upon which to base expected worker exposure levels for one identified primary hazardous aerosols.
2. Final decision tool in health and safety issues related making recommendations of protective actions to biomass production.

Note: We have attached the new spreadsheet with both pre-cut and post-cut timelines. The Task 2 in the pre-cut timeline was removed however we will still include some of that content (handling of biochar) in Task 1, but it will not be as in-depth as originally planned. In other words it is not a complete task but a small part of one. The Task 3 was also reduced from doing a full analysis on several aerosols to a pilot study on one selected aerosol.

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OBJECTIVE 8

(Revised 11.11.11)

	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
Objective 8 - Education	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Task 1 - Course module development																				
Task 2 - 8-week research internship experiences																				
Task 3 - Native Perennial Grass Bioenergy 2-week Intensive Program (NAPERG-IP)																				

Deliverables and Metrics:

Year 1

1. 5 course modules developed (e.g. Adobe Flash multimedia and appropriate assingments); each with sufficient content for 4-6 hours of face-to-face educational experiences
2. 12 graduates from a structured 320 hour paid research internship in project labs
3. 8 monthly online research webinars

Year 2

1. 5 course modules developed (e.g. Adobe Flash multimedia and appropriate assingments); each with sufficient content for 4-6 hours of face-to-face educational experiences
2. 12 graduates from a structured 320 hour paid research internship in project labs
3. 8 monthly online student seminars
4. 50 graduates from 2-week summer Intensive Program (IP) in Native Perennial Grass Bioenergy

Year 3

1. 5 course modules developed (e.g. Adobe Flash multimedia and appropriate assingments); each with sufficient content for 4-6 hours of face-to-face educational experiences
2. 12 graduates from a strucxtured 320 hour paid research internship in project labs
3. 8 monthly online student seminars

Year 4

1. 5 course modules developed (e.g. Adobe Flash multimedia and appropriate assingments); each with sufficient content for 4-6 hours of face-to-face educational experiences
2. 12 graduates from a strucxtured 320 hour paid research internship in project labs
3. 8 monthly online student seminars
4. 50 graduates from 2-week summer Intensive Program (IP) in Native Perennial Grass Bioenergy

Year 5

1. 12 graduates from a strucxtured 320 hour paid research internship in project labs
2. 8 monthly online student seminars

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Objective 9 - Extension and Outreach	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Task 1																				
Identify team of faculty and staff for each module/article/webinar topic																				
Develop learning objectives and outline for learning modules, webinars, and articles																				
Prepare video clips and content, edit and design modules; convert materials to on-line format; prepare articles and develop FAQs																				
Develop marketing materials to encourage Extension educators to participate in the on-line learning																				
Conduct webinar for each learning module																				
Develop and activate "Ask an expert" feature on CoPs																				
Develop and administer assessments/evaluation																				
Secure and upload images to CoP Flickr sites																				

Year 1 Deliverables

Deliverables: 2 learning modules, 2 webinars, and 4 eXtension articles re: a) Perennial grass establishment: variety selection, seed quality, seedbed prep, seeding depth; b) Post-establishment fertilizer: amount, kind, timing; c) Post-establishment weed control; images uploaded to eXtension Flickr sites

Deliverable: Online peer network for Extension Educators launched

Year 2 Deliverables and Metrics

Deliverables: 2 learning modules, 2 webinars, and 4 eXtension articles re: a) Biomass harvest systems; b) Biomass storage systems, costs, and consequences;
c) Economics of biomass feedstock production systems

Deliverables: Online curriculum for Extension Educators (eXtension Sustainable Agriculture Energy Community of Practice)

Deliverables: Identify topics for "Ask an Expert"; identify and activate "experts" for each topic

Metric: 100 Extension Educators and industry professionals will gain awareness and knowledge in bioenergy topics (indicator measured by online surveys six months following participation in learning activities)

Years 3-5 Deliverables and Metrics

Deliverables: 6 learning modules, 6 webinars, and 12 eXtension articles re: a) Pyrolysis conversion systems; b) Biochar utilization; c) Environmental impacts of perennials in the landscape; - d) Insect control; e) Plant diseases; f) Harvesting: timing, cutting height, environmental conditions including drought; g) producer decision support tools

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Objective 9 - Extension and Outreach	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4

<u>Metric:</u> 400 Extension Educators and industry professionals will gain awareness and knowledge in bioenergy topics (indicator measured by online surveys six months following participation in learning activities)

<u>Metric:</u> 250 Extension Educators will incorporate bioenergy learning activities into their educational outreach programs (indicator measured by online surveys six months following learning activities)

Extension and Outreach Task 2																				
Plan and conduct educational meetings, conferences, workshops, field days, media events, eXtension bioenergy learning modules, webinars, and networking activities about perennial biomass feedstocks, logistics, safety, processing, and economics; and utilization of pyrolysis biochar as a soil amendment for producers, agricultural industry, horticulturalists, educators, and agency personnel																				
Develop and utilize assessments of awareness and knowledge gained																				

Years 2-5 Deliverables

<u>Deliverables:</u> 100 educational meetings, conferences, workshops, field days, media events, eXtension bioenergy learning modules, webinars, and networking activities re: perennial biomass production BMPs; biomass logistics, safety, processing, economics; BMP for biochar as a soil amendment

<u>Metric</u>: 8,000 agricultural producers, agricultural industry leaders, educators, and agency personnel and 500 horticultural producers and industry leaders will: a) gain awareness and knowledge regarding environmental, economic, and public relations impacts of transitioning marginal crop land to perennial grass, b) understand the impacts of biochar as a soil amendment (indicator measured by post-event surveys)

Extension and Outreach Task 3																				
Recruit 2 producer cooperators/state to establish biomass demonstration plots; negotiate contracts																				
In cooperation with Objective 1 faculty, design biomass demonstration plot protocols																				

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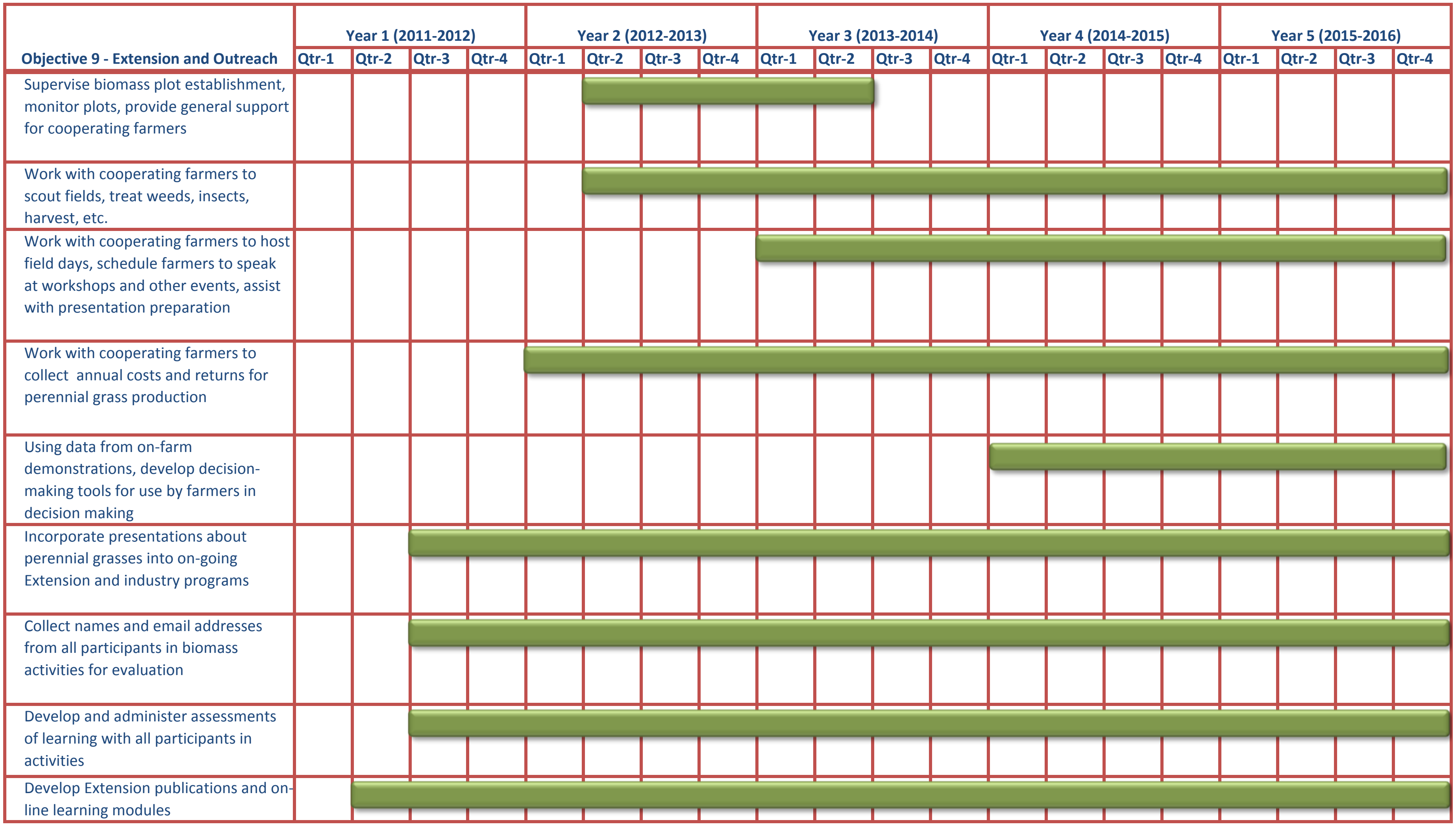

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	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
Objective 9 - Extension and Outreach	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Using data from research, demonstrations and trials, develop a set of decision tools for agricultural producers and agribusiness leaders to use to evaluate the economic prospects of the pyrolysis-biochar platform on their farming operations																				
Work with appropriate partners to create educational resources to help volunteers and youth learn about various aspects of carbon and nutrient cycling, biomass feedstocks production, biofuels production technologies, and utilization of biochar as a soil amendment																				
Provide educational resources developed through this project to Master Gardeners (MG), Junior Master Gardener (JMG) Leaders, and other community educators through local and state continuing education opportunities, such as State Master Gardener Conference and JMG training																				
Establish 15 perennial grass and biochar demonstration plots established and managed by youth across Indiana, Iowa, and South Dakota (including programs at two Native American reservations in South Dakota); Build connections to the National Junior Master Gardener program and Extension Master Gardeners																				

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	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
Objective 9 - Extension and Outreach	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Conduct assessments to measure youth and adult outputs and outcomes using online and electronic assessment tools																				
Develop supporting educational materials for educating volunteers, teaching materials for the volunteers to use, and social media for engaging Master Gardeners (MG) volunteers; post on-line																				
Develop MG volunteer job description for biochar demonstration and community gardens																				
Recruit and educate MG core volunteers (CVs) and identify demonstration sites. Develop learning package of teaching materials for MGs. Establish web presence and social media																				
Establish initial MG biochar demonstration gardens																				
Coordinate demo sites. Expand social media. Develop Learning Package for MGs and teachers to use for educational programs																				
MGCV and local MG county agents and volunteers recruit additional MGs																				
MGCV coordinate planting demonstration sites																				
Expand social media to serve as a communication vehicle to outside audiences																				
Create public blog including postings from JGs and photos or demo sites, calendars of tours and educational events, video clips, and links to other sites																				

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	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
Objective 9 - Extension and Outreach	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Collect names and email addresses of participants in events and on-line activities																				
Conduct assessments of knowledge gained and behavior changes																				

Years 1-5 Deliverables and Metrics

Deliverables: 8 on-going perennial biomass feedstock production demonstrations and 10 biochar field trials

Deliverables: 18 on-farm perennial crop field days and 18 on-farm biochar field days hosted by collaborating producers

Deliverables: Publicly avalable and accessible data, webinars, and online learning modules from the perennial grass demonstrations and biochar tirals

Deliverables: 10 community garden biochar demonstration plots established

Deliverables: Tests and documentation for federal and state approvals for use of biochar as a soil amendment

Deliverables: Decision tools for ag producers and leaders to evaluate economic prospects of the perennial crops and biochar

Deliverables: Learning modules for youth re: perennial grasses, carbon cycling, and biochar utilization

Deliverables: Evaluation and research data

Metric: 3,000 agricultural producers will gain knowledge of BMPs for establishing perennial grasses and/or utilizing biochar (indicators measured by pre/post activity surveys and open-ended questionnaires)

Metric: 750 horticulturalists and gardeners will gain knowledge regarding impacts of utilizing biochar in horticultural applications (indicators measured by pre/post activity surveys and open-ended questionnaires)

Metric: 5,000 4-H, FFA, and K-12 science students will gain awareness and knowledge of biomass production, biofuels production, and carbon and nutrient cycling topics after participating in youth activities (indicators measured by pre/post activity surveys and open-ended questionnaires)

Metric: 5,000 youth will gain awareness and knowledge related to careers in Science, Engineering, and Technology (SET) as a result of participating in 4-H, K-12 classroom and FFA learning experiences (indicators measured by pre/post activity surveys and open-ended questionnaires)

Extension and Outreach Task 4																				
Work with cooperating farmers to collect annual costs and returns for perennial grass production																				
Create whole-farm decision support tools for perennial grass production and biochar utilization and post online																				
Develop tutorial for using decision support tools; post online																				

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	Year 1 (2011-2012)				Year 2 (2012-2013)				Year 3 (2013-2014)				Year 4 (2014-2015)				Year 5 (2015-2016)			
Objective 9 - Extension and Outreach	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4	Qtr-1	Qtr-2	Qtr-3	Qtr-4
Develop workshop curriculum for use by Extension personnel to teach producers and ag industry leaders to use the tools																				
Collect names and email address for workshop participants and online users for evaluation purposes																				
Develop and administer assessment of learning																				

Research phases and timetable for a perennial forage breeding program.

Phase	Year 1	Year 2	Year 3	Year 4	Year 5
Phase 1: Germplasm acquisition & evaluation	Establish germplasm evaluation nurseries.	Evaluate forage yields, quality, and other traits	2^{nd} year of evaluation	Identify superior plants and move to crossing blocks, initial seed harvest	Harvest seed. Use seed in Phase 2. Synthetic populations may need to be random mated several generations.
Phase 2: Recurrent selection breeding program.	Establish selection nurseries using seed from selected germplasm sources.	Evaluate forage yields, quality, and other traits	2^{nd} year of evaluation	Identify superior plants and move to crossing blocks, initial seed harvest	Harvest seed, repeat cycle in breeding program. Use seed to plant regional trials.
Phase 3: Regional small plot trials	Plant trials	Harvest trials	Harvest trials	Summarize data, begin seed increase of best strains for pasture trials or field scale trials.	Seed harvested from increase nurseries
Phase 4: Field scale or grazing trials of advanced lines	Plant field or pastures trials.	Field or grazing trial production harvests.	Field or grazing trial production scale harvests.	Increase best strain for release. Continue to monitor trials.	Release seed to seed growers

Exhibit 2

United States Department of Agriculture
National Institute of Food and Agriculture
AWARD FACE SHEET

1. Award No. 2011-68005-30411	**Amendment No.** 3	**2. Proposal Number** 2013-06846	**3. Period of Performance** 08/01/2011 through 07/31/2014	**4. Type of Instrument** Grant	
5. Type of Action Revision	**6. CFDA Number** 10.310	**7. CAN**	**8.MO**	**9. Method of Payment** ASAP 6800530411680051300 0	**10. CRIS Number** 0225366

11.Authority:
7 U.S.C. 450i(b), Section 7406 of FCEA of 2008, P.L. 110-246, AFRI

12. Agency (Name and Address)
Awards Management Division
National Institute of Food and Agriculture/USDA
Washington, DC 20250-2271

13. Awardee Organization
Iowa State University of Science and Technology
Ames, IA 50011-2207

14. Program Point of Contact:
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Telephone: 202-401-1719
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Administrative Point of Contact:
Shynika Loften
Telephone: 202-401-6031
sloften@nifa.usda.gov

15. Project Director/Performing Organization
Kenneth J Moore
Iowa State University of Science and Technology
Ames, IA 50011-1010

16. Funding:

	Federal	Non-Federal
Previous Total	$14,818,025.00	$0.00
+ or -	$0.00	$0.00
Total	$14,818,025.00	$0.00
Grand Total	$14,818,025.00	

17. Funds Chargeable

FY - FDC	Amount	FY - FDC	Amount
13- 362-68005	$0.00		

18. Title of Proposal
Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (AFRI-CAP)

PROVISIONS

This Award incorporates the following:

1. The requested information has been received by this office and the NIFA cognizant program official. NIFA approves the request as indicated below:
2. The IRB approval has been received and approved by NIFA-USDA, therefore, grant funds in the amount of $5,000,000 are released for expenditure from Proposal Number 2013-05145. With this action, all funds for this award are now released.
3. All other Provisions on the Award Face Sheet dated 09/03/2013 remain in effect.

FOR THE UNITED STATES DEPARTMENT OF AGRICULTURE
This award, subject to the provisions above, shall constitute an obligation of funds on behalf of the Government. Such obligation may be terminated without further cause unless the recipient commences the timely drawdown of funds; such drawdowns may not exceed one year from issuance date of the award.

Typed Name	Signature	Date
Bruce Mertz Authorized Departmental Officer	BMERTZ	09/19/2013

ATTACHMENT A TO THE NIFA-2009

AWARD NUMBER: 2011-68005-30411

Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (AFRI-CAP)

Co-Project Directors:

Robert B Mitchell- USDA-ARS Northern Plains Area

Robert C Brown- Iowa State University of Science and Technology

Jill Elizabeth Euken- Iowa State University of Science and Technology

Douglas Karlen- USDA-ARS National Lab for Agriculture and the Environment

Michael Casler- USDA-ARS-NPA

Charles V. Schwab- Iowa State University

Dermot James Hayes- Iowa State University of Science and Technology

Keri Lee Jacobs- Iowa State University of Science and Technology

Akwasi A Boateng- USDA-Agricultural Research Service

Stuart Birrell- Iowa State University

Bruce Dien- USDA-ARS-MWA, NCAUR

Kenneth P. Vogel- USDA-ARS

Catherine L Kling- Iowa State University of Science and Technology

Sorrel Brown- Iowa State University of Science and Technology

David A Laird- Iowa State University of Science and Technology

D Raj Raman- Iowa State University of Science and Technology

Exhibit 3

2013 CenUSA Bioenergy Advisory Board

Tom Binder	Senior VP, Research Archer Daniels Midland	Tom.Binder@adm.com 217.451.228 Archer Daniels Midland Company, 1001 N Brush College Rd Decatur, IL 62521 US
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	John Deere	
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Eric Zach	Ag Program Manager Wildlife Division Nebraska Game & Parks Commission	Eric.Zach@Nebraska.gov (o) 402.471.5449 2200 N. 33rd St. Lincoln, NE 68503

The CenUSA Bioenergy project is supported by Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30411 from the USDA National Institute of Food and Agriculture.

Exhibit 4

CenUSA 2013 Annual Meeting at West Lafayette, IN, July 30 – Aug. 2, 2013

Date	Time	Agenda Item		Location	Transportation
July 30	11:30	Registration Opens		Beck Center	See Shuttle Schedule
	12:00 – 1245	Lunch – Brief Welcome	Jeff Volenec	Beck Center	
	12:45 – 1:00	Open meeting - Review Agenda – Introductions (VIP)	Ken Moore		
	1:00 – 1:45	**Objective 1 – Feedstock Development** (Focus on yield improvement)			
	1:45 – 2:30	**Objective 2 – Sustainable Feedstock Production System** (Focus on environmental impacts)			
	2:30 – 3:00	Break		Beck Center	
	3:00 – 3:45	**Objective 3 – Feedstock Logistics** (Include update on new baling technologies that are significantly increasing bale density)			
	3:45 – 4:30	**Objective 4 – System Performance Metrics**			
	4:30 – 5:30	**Producer/Coop/Econ Development Panel**			
	5:30 – 6:30	Shuttle to Restaurant		Sgt. Preston's	See Shuttle Schedule
July 31	7:45 – 8:30	Breakfast		Beck Center	See Shuttle Schedule
	8:30 – 12:30	**Field Tours** **Tour 1: Agronomy Center for Research and Education** View the CenUSA sustainability plots where, in addition to agronomic metrics, soil quality, water quantity/quality and GHG measurements are being made on biomass and conventional cropping systems. **Tour 2: Throckmorton Purdue Agricultural Center** View CenUSA factor analysis plots that focus on soil fertility and erosion studies.			Bus
	12:30 – 2:00	Lunch + Travel		TBD	
	2:00 – 3:00	**Overview of Thermochemical Processing –** Update on Status of Different Thermochemical Processing/Companies Active in Thermochemical Processing	Robert Brown		
	3:00 – 3:45	**Objective 5** – Feedstock Conversion/Refining + Brief Review of Thermochemical Processing			
	3:45 – 4:00	Break		Beck Center	
	4:00 – 4:45	**Objective 6 – Markets & Distribution**			
	4:45 – 5:30	**Objective 7 – Health & Safety**			
	5:45 – 7:15	Social Time with Poster Presentations (Cash Bar) Dinner on your own		Beck Center	See Shuttle Schedule
Aug 1	7:45 – 8:30	Breakfast		Beck Center	See Shuttle Schedule
	8:30 – 9:15	**Objective 8 – Education**			
	9:15 – 10:00	**Objective 9 – Extension and Outreach**			
	10:00 – 10:15	Break		Beck Center	
	10:15 – 12:15	**Panel – NIFA AFRI CAP Project Directors**			
	12:15 – 1:15	Lunch		Beck Center	
	1:15 – 5:00	**Breakout Sessions** Each objective set their own agenda		Extension has it's own room	
		Dinner on your own			
Aug 2	7:30 – 8:30	Breakfast		Beck Center	See Shuttle Schedule
	8:30 – 9:45	**Advisory Board Panel - Comments**	Moderator: Ken Moore		
	9:45 – 10:00	Break		Beck Center	
	10:00 – 11:30	**USDA NIFA Comments**	Moderator: Ken Moore		
	11:30	Adjourn			See Shuttle Schedule

CenUSA Bioenergy is supported by Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30411 from the USDA National Institute of Food and Agriculture.

SHUTTLE SCHEDULE

2013 CenUSA Bioenergy Annual Meeting

July 30 – August 2, 2012
Purdue University
West Lafayette, IN

Tuesday, July 30, 2013

11 am-12:30pm	**Shuttles from Union Club Hotel to Beck Agricultural Center** Depart from the Union Club Hotel (Go out the hotel main entrance and buses will load on Grant Street in front of the Parking Garage) *Shuttles depart approximately every 30 minutes. Times may vary slightly.*
5:30pm	**Buses Depart Beck Agricultural Center for Sgt. Prestons for Dinner**
7:30-8:00pm	**Buses Depart Sgt. Prestons and return to Union Club hotel** *Shuttles depart approximately every 30 minutes. Times may vary slightly.*

Wednesday, July 31, 2013

7:15 and 7:30am	**Shuttles from Union Club Hotel to Beck Agricultural Center** Depart from the Union Club Hotel (Go out the hotel main entrance and buses will load on Grant Street in front of the Parking Garage) *Shuttles depart approximately every 30 minutes. Times may vary slightly.*
8:30 am	**Buses Load and depart for Tours**
6:15-7:30pm	**Buses Depart Beck Agricultural Center and return to Union Club hotel** *Shuttles depart approximately every 30 minutes. Times may vary slightly.*

Thursday, August 1, 2013

7:15 and 7:30am	**Shuttles from Union Club Hotel to Beck Agricultural Center** Depart from the Union Club Hotel (Go out the hotel main entrance and buses will load on Grant Street in front of the Parking Garage) *Shuttles depart approximately every 30 minutes. Times may vary slightly.*
5:00pm	**Buses Depart Beck Agricultural Center and return to Union Club hotel**

Friday, August 2, 2013

7:15 and 7:30am	**Shuttles from Union Club Hotel to Beck Agricultural Center** Depart from the Union Club Hotel (Go out the hotel main entrance and buses will load on Grant Street in front of the Parking Garage) *Shuttles depart approximately every 30 minutes. Times may vary slightly.*
10:45am-12:15pm	**Buses Depart Beck Agricultural Center and return to Union Club hotel** *Shuttles depart approximately every 30 minutes. Times may vary slightly.*

Exhibit 5

CenUSA Bioenergy
Iowa State University Project Participants

* = **Cenusa 2013 Annual Meeting Attendees**

Name	Institution	Project Role	Email
Fred Baxendale	University NE-Lincoln	Objective 9 Collaborator Producer Research Plots/Perennial Grass	fbaxendale1@unl.edu
Albert (Bert) Bennett	ICM, Inc.	Advisory Board Member	Albert.Bennett@ICMINC.com
Jamie Benning	Iowa State University	Objective 9 Collaborator • Producer Research Plots/Perennial Grass	benning@iastate.edu
Tom Binder *	ADM	Advisory Board Member	amber.reynolds@adm.com
Stuart Birrell *	**Iowa State University**	**Objective 3 CoPd**	**sbirrell@mail.iastate.edu**
Akwasi Boateng *	USDA-ARS	Objective 1 Collaborator	akwasi.boateng@ars.usda.gov
Greg Brenneman *	Iowa State University	Objective 9 Collaborator • Producer Research Plots, Perennial Grass	gregb@iastate.edu
Sylvie Brouder *	Purdue University	Objective 2 Collaborator	sbrouder@purdue.edu
Robert Brown *	**Iowa State University**	**Objective 5 CoPd**	**rcbrown@iastate.edu**
Sorrel Brown *	**Iowa State University**	**Objective 9 CoPd** • Evaluation/Administration • Extension staff training, eXtension	**sorrel@iastate.edu**
Mark Carlton	Iowa State University	Objective 9 Collaborator	mcarltn@iastate.edu
Natalie Carroll *	Purdue University	Objective 9 Collaborator • Broader Public/Master Gardner/Youth Programs	ncarroll@purdue.edu
Michael Casler *	**USDA-ARS**	**Objective 1 CoPd** Objective 2 Collaborator	**michael.casler@ars.usda.gov**
Indrajeet Chaubey *	Purdue University	Objective 2 Collaborator	ichaubey@purdue.edu
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Exhibit 6

CenUSA Annual Meeting: Field Tour Agenda

July 31st, 2013

Purdue University,

West Lafayette, IN

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cenusa bioenergy

ACKNOWLEDGMENTS

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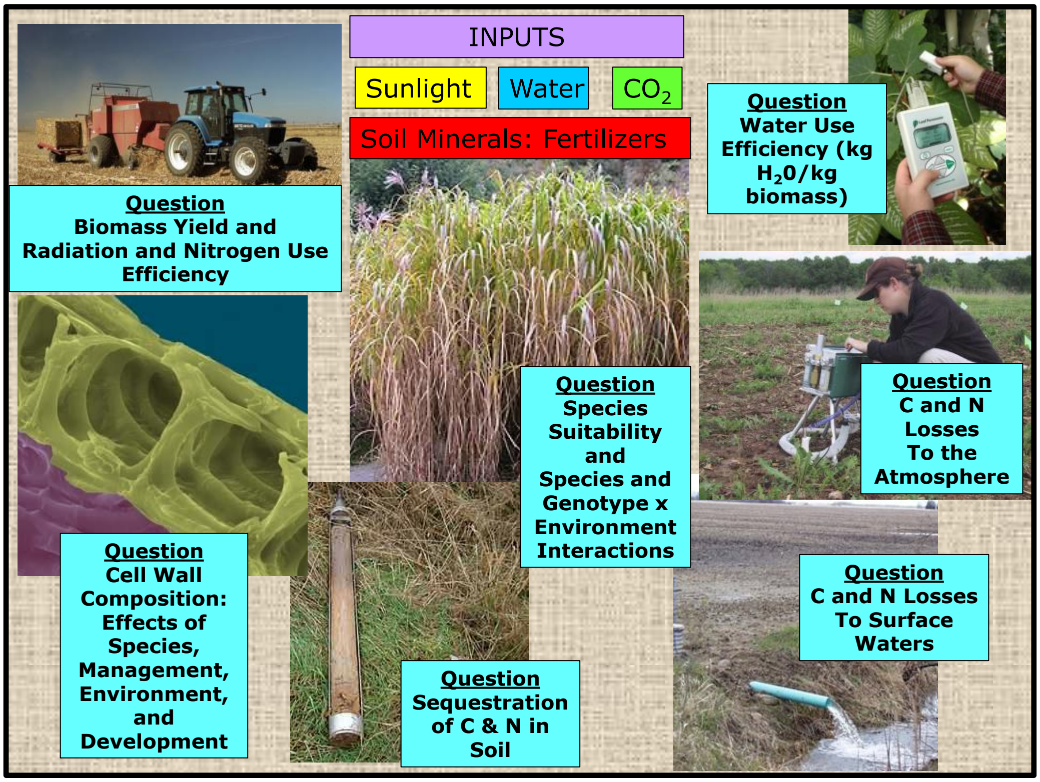
Editors: Mary-Jane Orr and Sayde Uerkwitz

Creative Design: Elizabeth Trybula

TOUR AGENDA

Time	Activity	Fact sheet (Page no.)
8:30 to 8:45	Transport to Water Quality Field Station (WQFS)	1 to 2
8:45 to 9:15	Field Presentation: Sylvie Brouder	3 to 4
9:15 to 9:45	Field Presentation: Mary-Jane Orr	5 to 6
9:45 to 10:15	Field Presentation: Elizabeth Trybula	7 to 8
10:15 to 11:15	Transport to Throckmorton – Purdue Agricultural Center (TPAC)	9 to 10
11:15 to 11:45	Field Presentation: Amanda Montgomery	11 to 12
11:45 to 12:15	Field Presentation: Ryan Dierking	13 to 16
12:15 to 12:45	Field Presentation: Monique Long	17 to 18
12:15 to 12:45	Field Presentation: Keith Johnson	19
12:45 to 1:15	Transport to Agronomy Center for Research and Education (ACRE) Beck Center	-
1:15 to 2:00	Lunch at Beck Center	-



The following funding sources for the Water Quality Field Station are gratefully acknowledged:

- Purdue University College of Agriculture
- Purdue University Center for the Environment
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- USDA/DOE Northcentral Sungrant Program
- National Pork Producers
- Purdue University Showalter Trust
- US Environmental Protection Agency
- US National Science Foundation
- USDA Consortium for Agricultural Soils Mitigation of Greenhouse Gasses
- USDA CSREES National Integrated Water Quality Program
- International Plant Nutrition Institute
- USDA Special Grants Program
- Eli Lilly Foundation
- US Department of Energy
- Indiana Department of Environmental Management

THE WATER QUALITY FIELD STATION (WQFS) ~ A PURDUE UNIVERSITY CORE FACILITY

A unique in-field laboratory for integrated studies of agricultural productivity and environmental impacts

Sylvie Brouder - WQFS Director*, Niki De Armond - WQFS Managing Director*

Agronomy Department, Purdue University

FACILITY GOAL

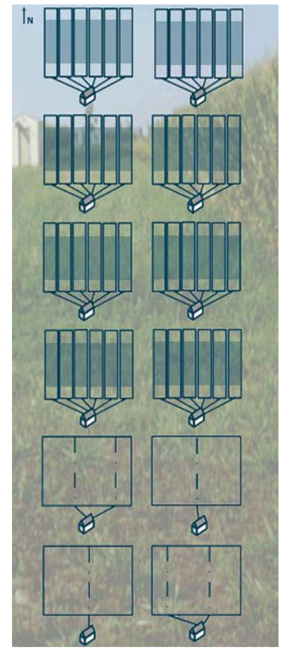
Advance the understanding of the unbreakable link between agricultural productivity and environmental stewardship. Provide an infield laboratory for studying mechanisms & processes governing productivity & environmental impacts of management technologies (e.g. ag, chemicals, nutrients, manure constituents) emphasizing quantitative assessment of soil, air & water quality.

VALUE to R/T/E

Established field laboratory with legacy data for:

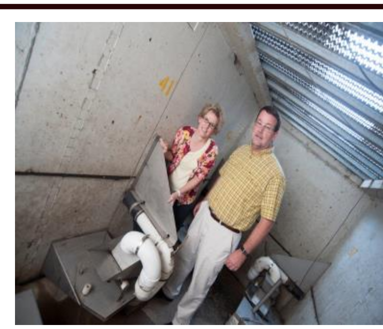
1. Comparison of productivity & environmental costs / co-benefits of emerging cropping systems w/ current systems &/ or native prairie;
2. Success evaluation of theoretically improved management strategies;
3. Educating students & the general public on critical issues of the agriculture-environment interface.

BRIEF OVERVIEW



- Established in 1992; refurbished in 2013.
- Only fully-replicated, slurry walled, in-ground lysimeter study of this scope & magnitude in the US.
- Only facility in the humid region of the eastern cornbelt where 11 managements can be compared to a restored prairie to assess relative environmental impacts of cropping systems.
- 15+ year existing database of C/N cycling in commonly practiced production systems
- Data records for (i) hourly rainfall & tile drain volume for 54 individual tile lines, (ii) daily mass loss of NO_3-N & DOC, (iii) GHG emissions (various times), & (iv) crop productivity measures (various attributes)

EXAMPLES of PREVIOUS PROJECTS



Assessing the impacts of:

- Tile spacing on crop productivity & nutrient loss to surface water
- Land application of swine manure on movement of nutrients (N &P) & bacterial pathogens to surface water
- Precipitation & swine manure management on fate & transport of pharmaceuticals & antibiotics in soils to water
- Crop rotation, fertilizer & manure management on N use efficiency, greenhouse gas emissions & C sequestration, C/N biogeochemical cycling, & C/N losses to surface water

Model Parameterization / Calibration / Verification ~ e.g. DRAINMOD N; SWAT, Hybrid Maize

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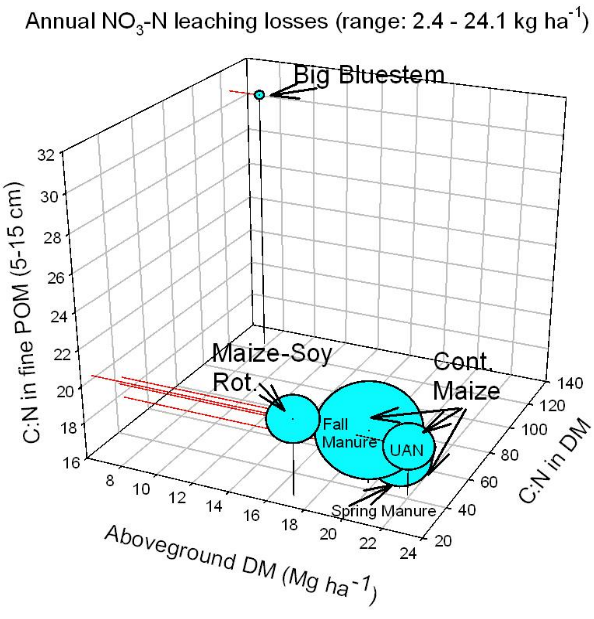
In 2007, several treatments were converted to candidate bioenergy systems. Switchgrass (upland ecotype "Shawnee") and Miscanthus (M x giganteus) were established from seed (5/2007) and 1kg transplants (5/2008), respectively. Two additional maize-based treatments were converted to annual bioenergy systems: dual purpose (grain + biomass) sorghum & no-till, continuous maize with residue removal. The native prairie was harvested instead of burned.

PREVIOUS RESEARCH HIGHLIGHTS TRADEOFFS IN GxExM & ECOSYSTEM SERVICES



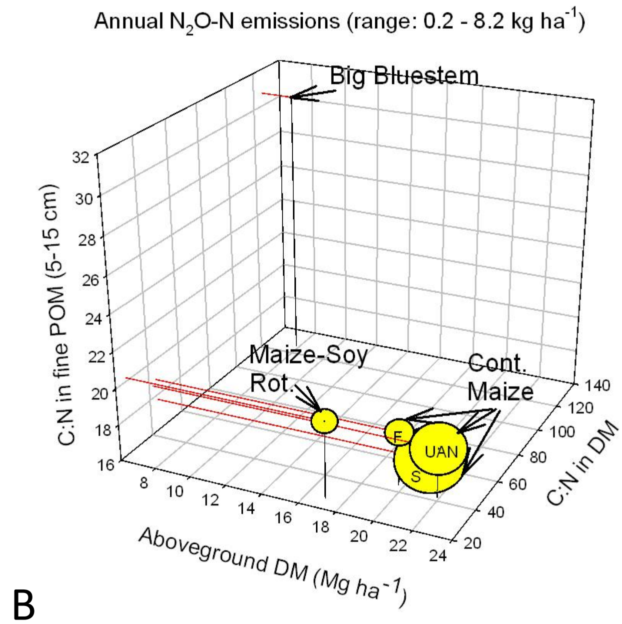


Fig.1. *Annual nitrate-N leaching losses (A) and nitrous oxide-N emissions (B) plotted as a function of total aboveground dry matter (maximum biomass), C:N ratio in the aboveground dry matter, & C:N ratio in the fine particulate organic matter in soil. The size of the bubble indicates the relative magnitude of loss among systems (kg ha^{-1} range given above each graph). Systems compared are a maize-soybean rotation (sidedress UAN at 135 kg N ha^{-1}; values averaged over both crops), continuous maize receiving N as sidedress UAN (157 kg N ha^{-1}), as fall (F) & as spring (S) manure (255 ± 24 kg N ha^{-1}), & an unfertilized, big bluestem-dominated prairie (0 N fertilizer).*

NEXT STEPS

- Analysis of WQFS bioenergy system impacts on soil, air & water quality is on-going;
- WQFS results are benchmarking on-going systems comparisons on marginal lands;
- Results from perennial systems have been used to parameterize SWAT for switchgrass & *Miscanthus*; SWAT is being used to simulate watershed-scale impacts & optimizations.

PUBLICATIONS (synthesized in figure)

Hernandez-Ramirez, G., S.M. Brouder, D.R. Smith, and G.E. Van Scoyoc. 2009. Carbon and nitrogen dynamics in an eastern corn belt soil: N Source and Rotation. Soil Sci. Soc. Am. J. 73:128-137.

Hernandez-Ramirez, G., S.M. Brouder, D.R. Smith, and G.E. Van Scoyoc. 2009b Greenhouse gas fluxes in an Eastern Corn Belt soil: Weather, N source and rotation. J. Environ. Qual. 38:841-854.

Hernandez-Ramirez, G., S.M. Brouder, D.R. Smith, G.E. Van Scoyoc and Greg Michalski. 2009c. Nitrous oxide production in an Eastern Corn Belt soil: Sources and redox range. Soil Sci. Soc. Am. J. 73:1182-1191.

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ECO-PHYSIOLOGY OF THREE PERENNIAL BIOENERGY SYSTEMS ~ *Miscanthus* x *giganteus*, switchgrass, & a big bluestem-dominated prairie

***Jennifer L Burks*[1]**, *S. M Brouder*[2], *J.J Volenec*[2] & *D. Allen*[3]

[1]Congressional Science Fellow for CSSA/ASA/SSSA/AAAS; [2] Dept. of Agronomy., Purdue Univ.; [3] Shell International Exploration & Production, Inc.

OBJECTIVES

The goal is an enhanced understanding of the comparative bioenergy production potential, nutrient cycling and ecosystem impacts of 3 candidate systems including quantification by season of:

1. above- & belowground biomass production;
2. tissue macronutrient accumulation & cycling;
3. accumulation of organic reserves, &
4. N fertilization effects on system attributes

IMPACT

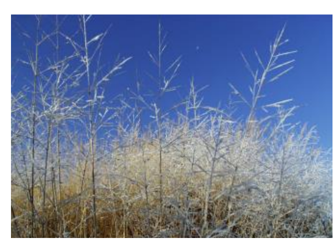
- Systems differ in biomass productivity-a key driver of system net energy balance.
- High biomass yield requires high inputs of N, P, and K – there is no free lunch.
- Tremendous pools of dry matter & C reside below ground & these pools may aid C sequestration

APPROACH

- Conducted at the WQFS.
- Experimental design: RCBD w/ 4 replicates.
- Treatments:
- Prairie (P: est. 1992); burned periodically until 2007; now harvested; 0 N applied;
- Switchgrass (S: est. 2007; upland ecotype "Shawnee"); 20 kg ha^{-1} PLS; 50 – 57 kg N ha^{-1} yr^{-1} as Agrotain-coated urea (2009 – 2011), &
- *Miscanthus x giganteus* (M: est. 2008); 1 L pots planted on 1 m^2 centers; N fertilizer as for switchgrass.
- N microplots outside the lysimeters: 0 (M & S), 56 (P), 112 (all) & 168 kg N ha^{-1} yr^{-1}.
- Above- & belowground (stem bases, rhizomes, fine roots) sample collection: Monthly April – Oct., Dec. (2009 – 2010); Mar., Aug., Oct., Dec. (2011).
- Tissue analyses: Total nutrient content (C, N, P, K), sugar, starch, proteins, amino acids, cellulose, hemi-cellulose, & lignin.

KEY FINDINGS

- Biomass yield of *Miscanthus*>switchgrass>unmanaged prairie.
- Prairie partitions more biomass belowground, while *Miscanthus* partitions rel. more biomass aboveground.
- Nutrients (N, P, and K) cycle seasonally in all systems, being mobilized from belowground organs in spring & sent to these organs in autumn.
- The C/N ratio of all systems is similar in Aug., but is higher in *Miscanthus* in Dec. as these plants partition biomass N preferentially to roots and rhizomes.
- Whole-plant accumulation of N, P, & K in *Miscanthus* is ca. 300, 50, and 500 kg ha^{-1}; about double that needed by switchgrass.
- Root mass of *Miscanthus* is very low, but this species has large well-developed rhizomes where sugars, starch, & N reserves accumulate.



Comparative analysis of productivity potential & environmental impacts is key to informing policies & strategies aimed at solving the energy grand challenge facing the US & the world, while at the same time feeding 10 billion people by 2050.

RESULTS & PRELIMINARY DATA

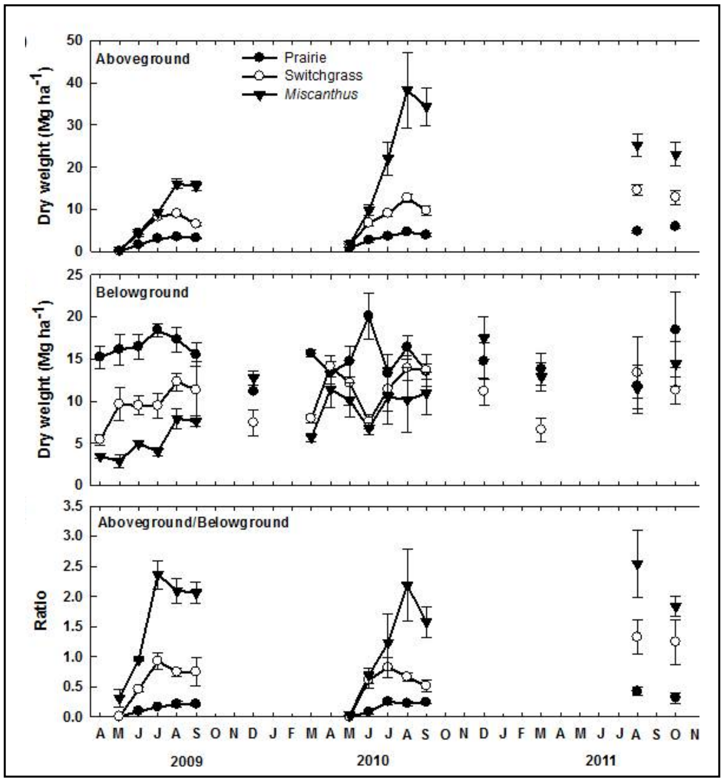
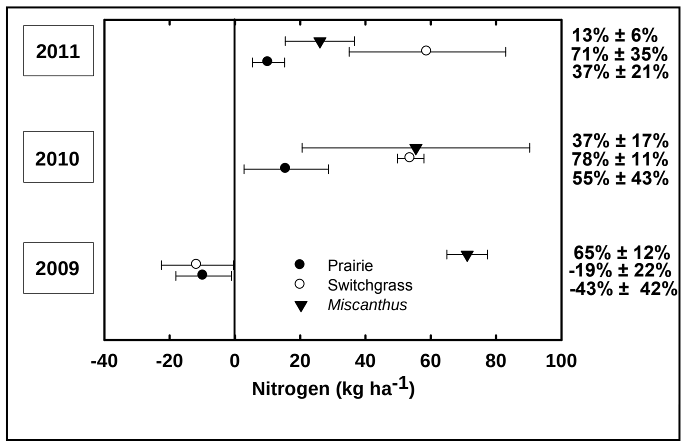


Fig.1.right. *Aboveground biomass yield ranks in order: Miscanthus > switchgrass>prairie. Comparatively, prairie produces the greatest belowground biomass; within 4 yrs of establishment, we observed very low root mass in Miscanthus. This species partitions relatively more biomass aboveground than the others.*

Fig.2.below. *Net accumulation of N (P, K too) in belowground organs occurs between Aug. & Dec. is high in switchgrass & Miscanthus. These nutrients support rapid regrowth the following spring.*



NEXT STEPS

- More long-term comparative studies aimed at understanding the input use efficiencies (water, N) of switchgrass, native prairies, & *Miscanthus* to other annual (maize, sorghum) & perennial (poplar) systems.
- Extend results to 'marginal' lands.
- Use findings to parameterize SWAT & other models permitting landscape-scale analysis of biomass production

PUBLICATIONS / PRESENTATIONS

Burks, J.L., J.J. Volenec, and S M. Brouder. 2013. Seasonal biomass accumulation and carbon partitioning in *Miscanthus x giganteus, Panicum virgatum* 'Shawnee', and an unmanaged prairie. GCB Bioenergy (draft).

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NITROGEN (N) CYCLE DYNAMICS IN BIOMASS PRODUCTION SYSTEMS: PATHWAYS FOR N LOSS MEDIATED BY SOIL BIOLOGY

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Purdue University / Agronomy Department

OBJECTIVES

This research will inform our understanding of the impact of biomass production strategies on belowground N and C transformations. Specific objectives include:

- Monitor "in-situ" GHG fluxes & soil N and C pools
- Predict future processes by quantify soil enzyme potential & understanding genetic markers
- Evaluate the interaction between biotic and abiotic drivers

IMPACT

Our work supports the assessment and development of agricultural management approaches for the sustainable production of both food and bioenergy products. Unique field capabilities for side-by-side comparative analysis facilitate study of:

- C and N losses to the atmosphere
- Soil sequestration of C and N

APPROACH

Using the Water Quality Field Station (WQFS) and Throckmorton (TPAC) experimental field sites:

- Biomass systems assessed: no-till continuous maize, dual purpose sorghum, switchgrass, *Miscanthus* x. *giganteus*, mixed native prairie
- Weekly field measure of GHG fluxes (GRACEnet)
- Soil sampled for laboratory analysis of enzyme activity, functional genetic markers, physiochemical properties

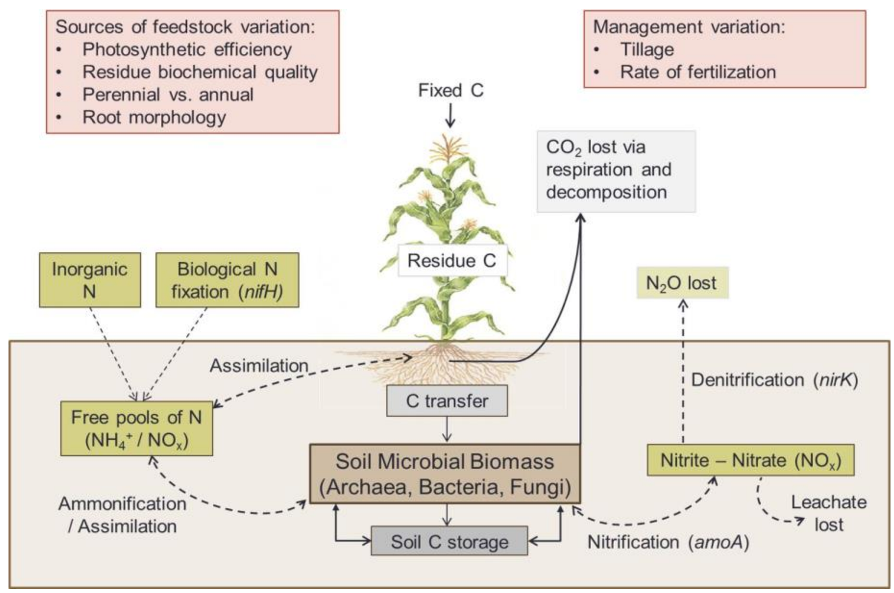

Fig.1. *Schematic of targeted N and C transformations*

KEY FINDINGS

- Biomass production system establishment is influential in altering pathways of N loss
- Emergence of distinct functional microbial communities associated with biomass production systems
- Trends between in-situ measures, soil assays and genetic markers

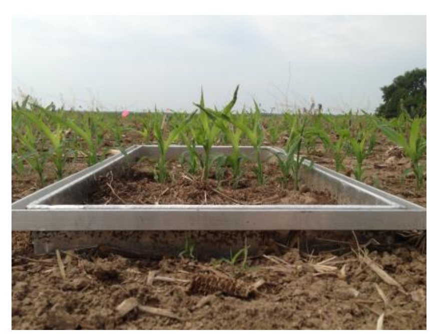

Fig.2. *GRACEnet GHG sampling base frame*

In a side-by-side comparison we were able to demonstrate clear distinctions in pathways of system N loss according to N cycle enzyme potentials over the establishment period in respective cropping systems. Relative to conventional maize, the prairie, switchgrass and sorghum systems trended toward lower capacity for N loss via nitrate leaching and nitrous oxide emissions. Ensuing work aims to link potential N transformations with "in situ" assays reflective of environmental conditions.

RESULTS & PRELIMINARY DATA

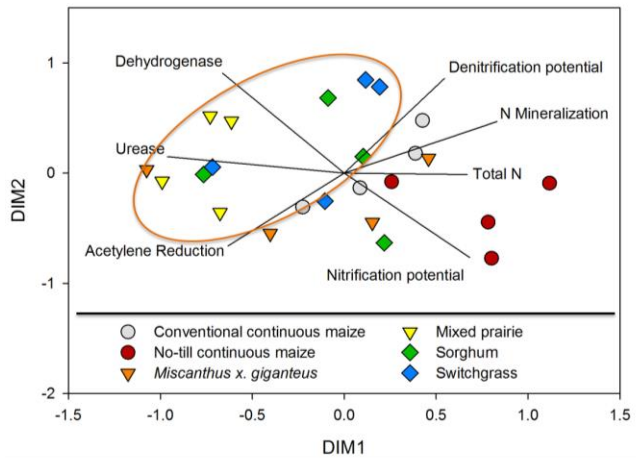

Fig.3. *Biplot representation of Principal Component Analysis (PCA) of N cycling measures. Total variance explained 63.2%; PC1(39.7%):PC2(23.5%). Clustering of field replicates illustrates separation along x-axis of cropping systems following 2-years of establishment at WQFS field site (2011). Circle highlights similarity between mixed prairie, switchgrass and sorghum systems*

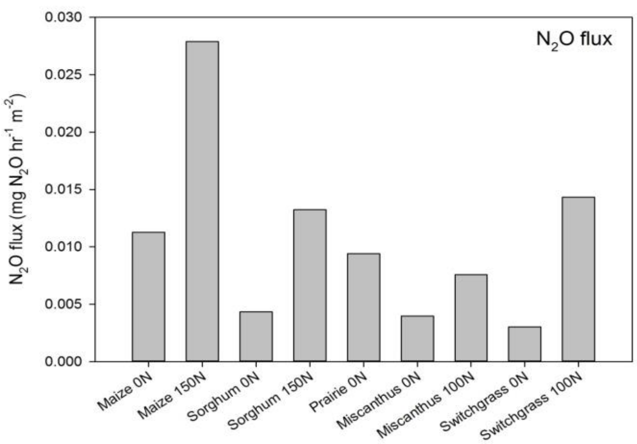

Fig.4. *Baseline GHG emissions of N_2O from a subset of the Factor Analysis Plots at the TPAC field site. Figure presents data averaged over weekly measures taken April 22 to May 7, 2013 prior to field activities. Pattern of enhanced N_2O flux with N additions in both annual and perennial systems, however sorghum flux demonstrates similarity with the perennial crops.*

NEXT STEPS

- Continued comparative analysis of potential biomass feedstocks influence on biogeochemical pathways
- Increased sampling efforts to link enzymatic potential with "in situ" monitoring
- Apply multivariate statistics to evaluation the interaction between abiotic and biotic drivers of GHG emissions

PUBLICATIONS / PRESENTATIONS

- Orr, M-J. (2012). Comparative assessment of five cellulosic biofuel management strategies: Implications to soil carbon and nitrogen dynamics. (Doctoral dissertation). Purdue University, West Lafayette, IN.

CONTACT INFORMATION

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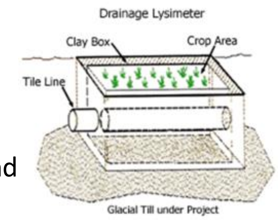
ECOHYDROLOGIC IMPACTS OF PERENNIAL PHIZOMATOUS GASSES ON TILE DISCHARGE AT THE PURDUE UNIVERSITY WATER QUALITY FIELD STATION

Elizabeth Trybula[1,3], *Indrajeet Chaubey*[2], *Jane Frankenberger*[2], *Sylvie Brouder*[3], *Jeff Volenec*[3]

[1]Ecological Sciences and Engineering IGP, [2]Department of Agricultural and Biological Engineering, [3]Department of Agronomy

OBJECTIVES



Quantify changes in:

- tile drain event volume,
- nitrate-N concentration, and
- nitrate-N load

due to transition from annual cropping systems into candidate bioenergy cropping systems *Miscanthus* and Shawnee switchgrass.

IMPACT

Bioenergy Production Transitions

As the United States pursues bioenergy development, *Miscanthus x giganteus* and *Panicum virgatum* are candidate cropping systems that may replace annual commodity crops in certain locations in the Midwest.

Cropping System Ecohydrology

Key physiological and morphological differences between cropping systems may alter hydrologic response. This work addresses how subsurface hydrology responds when corn cropping systems are replaced with perennial grass monocultures.

APPROACH

- Paired regression analysis on tile lysimeter event volume was used to quantify before and after effects of treatment (Clausen & Spooner, 1993)
- Exploratory analysis of long-term tile drain nitrate-N concentrations before, during, & after transition
- Event-based nitrate load calculation during the treatment period

CALIBRATION Prior Management (1995-2006/2007)	TREATMENT Current Management (2007/2008 - 2011)
Corn-Soybean Rotation 157 kg N ha $^{-1}$	Continued
Continuous Corn 180 kg N ha $^{-1}$	Continued
Mixed Prairie (annual burn)	Mixed Prairie (residue removed)
Corn-Soybean Rotation 180 kg N ha $^{-1}$	Shawnee Switchgrass 50 - 55 kg N ha $^{-1}$
Corn-Soybean Rotation 180 kg N ha $^{-1}$	*Miscanthus x giganteus* 50 - 55 kg N ha $^{-1}$

**Establishment Period (2007-2009); Switchgrass seeded in 2007; Miscanthus transplanted in 2008*

KEY FINDINGS

Tile Drain Flow Event Volume

- *Miscanthus* consistently decreased net tile drain event volume
- Switchgrass increased or decreased net tile drain event volume depending on the plot replicate
- Potential seasonal differences via evaporative and transpiration influenced reductions in soil moisture and event-based preferential flow

Drain Nitrate Concentration & Load

- Switchgrass & *Miscanthus* systems decreased nitrate leaching in tiles
- *Miscanthus* reduced nitrate concentration and load more than mixed prairie or switchgrass
- Seasonal nitrate load fluctuations occurred in switchgrass and mixed prairie systems

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Switchgrass and Miscanthus establishment altered the quantity and quality of subsurface drainage at the field scale. While water-limited Miscanthus decreased tile drain event volume consistently, switchgrass both increased and decreased tile drain event volume depending on the plot replicate. Both grasses significantly reduced nitrates in tile drainage. While clear benefits to water quality may exist, scaling impact to the catchment and watershed is a next step to understanding the potential impact of feedstock production.

RESULTS & PRELIMINARY DATA

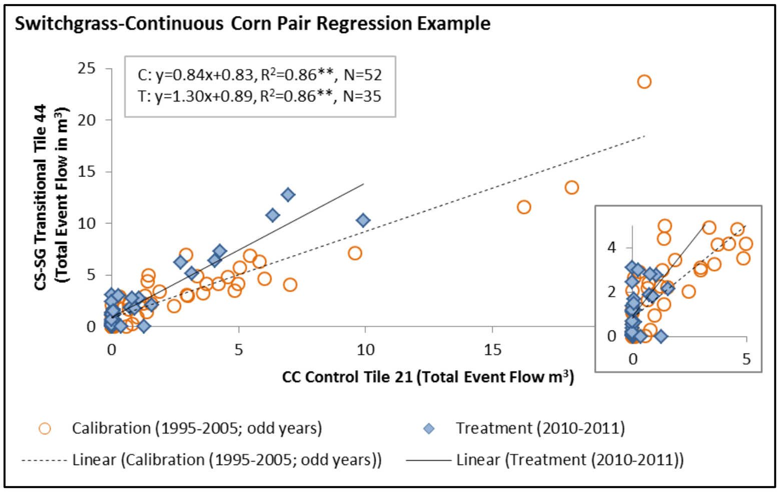
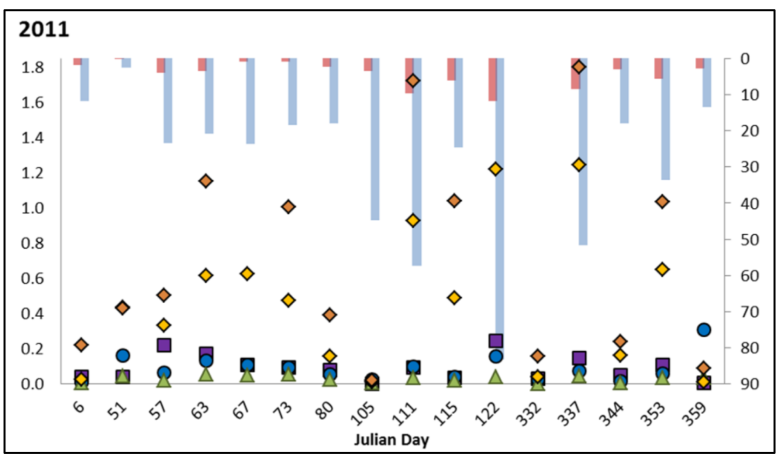


***Figure above**: replicate demonstrates significant increase in tile drain event volume due to establishment of switchgrass.*
***Paired relationship ANOVA significant at p=0.00*



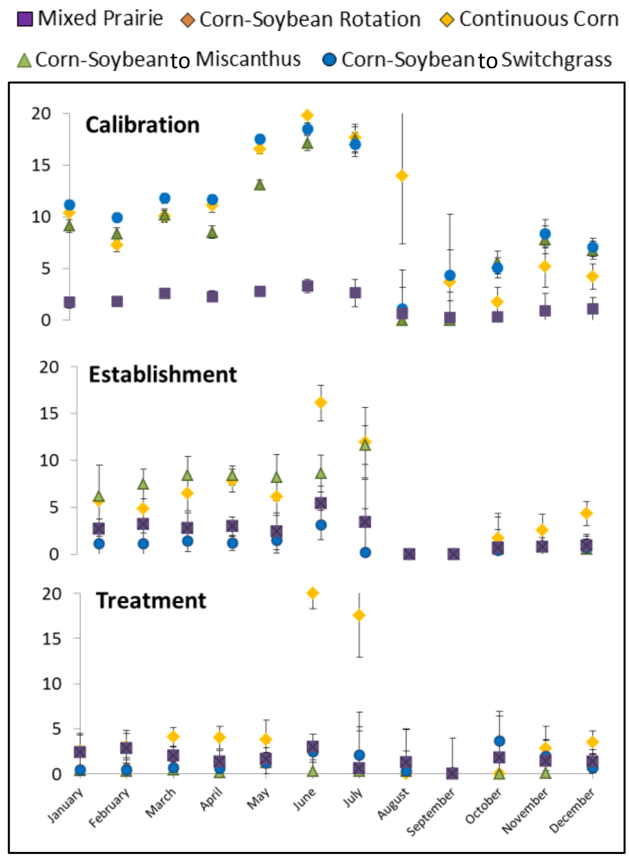


***Figure above:** average monthly tile drain nitrate concentration by cropping system. Establishment of Miscanthus and switchgrass decreased nitrate concentrations to values observed in long-term mixed prairie plots within three years.*
***Figure right:** cropping system nitrate load with respect to precipitation volume and intensity for each recorded event in 2011.*

Mean event precipitation intensity (mm/hr) Total Event Precipitation (mm)

NEXT STEPS

- Increase the size of existing dataset to identify seasonal characteristics affecting net volume
- Include soil moisture data in event analysis to construct plot water balance
- Integrate event data with modeled outputs at the catchment and watershed scales

PUBLICATION

Trybula, E. (2012). *Quantifying ecohydrologic impacts of perennial rhizomatous grasses on tile discharge….* (Order No. 1535171, Purdue University).

CONTACT INFORMATION

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Agricultural Research at Purdue

Throckmorton-Purdue Agricultural Center (TPAC)

www.agriculture.purdue.edu/PAC

Research Overview

TPAC is unique in its close proximity to campus. It is home to almost one-third of Purdue agricultural research projects, with current work involving 30 different crops. Research focuses on weed management, insect management, soil fertility, agronomic crop production, ornamentals, fruit and vegetable production, biological controls, systems engineering, hardwood production, woodland and habitat management, and resistance management of weeds and insects. New areas of interest include organic and high tunnel vegetable production.

Size and topography

- More than 830 managed acres five miles south of Lafayette along U.S. 231 in Tippecanoe County; 567 acres tillable
- Rolling silt loam soils at the original farm and some variation across the Meigs addition
- Two active manmade wetlands
- 20 acres of timber used for forestry research

Resources

- Six high tunnels in operation
- Crops processing facility with two walk-in coolers for produce and plant materials
- At the Meigs Farm, 145 acres set up for drip and overhead irrigation, and the site has been extensively tiled for optimum drainage
- Five full-time employees, including a horticulture crops manager and specialty crops specialist
- Seasonal labor
- Twilight tours, topic-specific workshops, biannual pruning workshop

Jay Young
Superintendent
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Heritage

Dr. George Throckmorton gave the farm to Purdue Agriculture in 1935 in memory of his father Edmund. It was deemed the "Edmund Throckmorton Farm Memorial" as a tribute to this pioneer leader of Tippecanoe County. In the late 1990s, horticultural and specialty crop research was relocated from the old Horticultural and O'Neall Memorial Farms to the Meigs Farm, which is part of TPAC. The center today encompasses four separate pieces – the home farm, Meigs North, Meigs South, and Meigs East.

Sample Research Projects

High Tunnel Bedding Plant and Cut Flower Research

Evaluate high tunnel bedding plant and field cut flower production.

Roberto Lopez, Michael Ortiz, and Tyler Mason, Department of Horticulture & Landscape Architecture

Bioenergy Crops for Indiana

Evaluate the productivity and soil and water impacts of converting marginal corn-soybean cropland to herbaceous and woody bioenergy crops.

Pat Murphy, Department of Agricultural & Biological Engineering

Beneficial Insects in Soybean Fields

Use of soybean fields at the Meigs Farm for insect sampling.

Ian Kaplan, Department of Entomology

Wine Grape and Small Fruit Research Studies

Evaluate various varieties of wine grapes and small fruit.

Bruce Bordelon and Paul Howard, Department of Horticulture & Landscape Architecture

TPAC is home to almost one-third of Purdue agricultural research projects, with current work involving 30 different crops

The Eight PACs

- Davis Purdue Agricultural Center (DPAC)
- Feldun-Purdue Agricultural Center (FPAC)
- Northeast-Purdue Agricultural Center (NEPAC)
- Pinney-Purdue Agricultural Center (PPAC)
- Southeast-Purdue Agricultural Center (SEPAC)
- Southern Indiana Purdue Agricultural Center (SIPAC)
- Southwest-Purdue Agricultural Center (SWPAC)
- Throckmorton-Purdue Agricultural Center (TPAC)

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It is the policy of Purdue University that all persons have equal opportunity and access to its educational programs, services, activities, and facilities without regard to race, religion, color, sex, age, national origin or ancestry, marital status, parental status, sexual orientation, disability or status as a veteran. Purdue University is an Affirmative Action institution.

TPAC EAST: A LOOK AT SURFACE WATER LOSSES, BIOMASS PRODUCTION & CLIMATE CHANGE

Amanda Montgomery, *Ruoyu Wang, Indrajeet Chaubey, Keith Cherkauer*

Purdue University / Agricultural & Biological Engineering

OBJECTIVES

As a part of a DOE & USDA jointly funded project, this site is an opportunity to

1) Quantify water use and water quality impacts relative to biomass yield on sloping marginal lands.

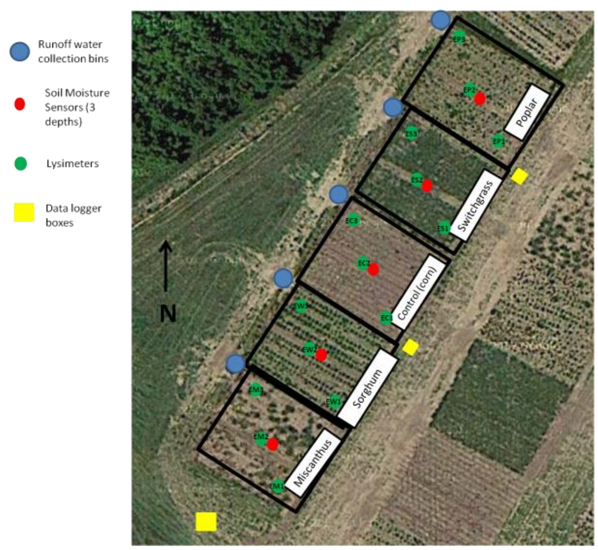
2) Explore the interaction among climate variability, hydrology, water quality and the growth of various biofuel crops to quantify long-term sustainability.

IMPACT

- Acreage devoted to Biofuel crops is expanding nationally as producers attempt to meet demand.
- Future production is expected to focus on marginal lands that are less than optimal for food crop production.
- There is limited information on how such crop management will affect water resources.
- Measurements collected at this field site will be invaluable to developing management strategies.

APPROACH

- Biofuel plots are installed on sloping site with a shallow restrictive layer that has made it a less than ideal location for food crop production.
- The site incorporates four replicates each with 5 plots growing one of five potential biofuel feedstocks: Miscanthus, switchgrass, sorghum, hybrid poplar, and corn (control)
- One of the replicate plots has been instrumented for water quantity/quality data collection



KEY PLANS

- Management:
  - Two Crops (BMR dual purpose sorghum, corn) fertilized with 150 kg/ha nitrogen, two (Miscanthus, switchgrass) fertilized with 50 kg/ha nitrogen
  - One Crop (Poplar) not fertilized
- Sampling plans:
  - Soil moisture & temperature- hourly data- 3 depths (10, 20, & 30 cm)
  - Weather station- hourly data - since Jan 2013
  - Runoff tanks - collected less than 2 days following a rain event with runoff
  - Suction cup lysimeters- sampled variably based upon season/weather- occurring most often during wet spring season

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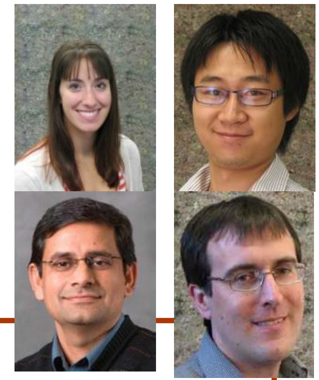

Most of the perennial crops are now in their second year of growth while the full monitoring system has now been in place since January, so we anticipate being able to work with a full season of data this winter. Analysis will look for weaknesses in our current sampling strategy and for correlations between variables that might require additional attention.

RESULTS & PRELIMINARY DATA

Water Quantity: Time series plot of daily weather and soil moisture data (aggregated from hourly data)

Water Quality: Samples analyzed for: nitrate, ortho-phosphorus, total nitrogen & phosphorus, total suspended solids

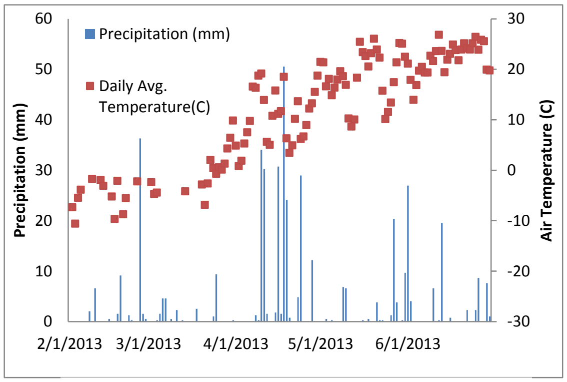

Fig.1. *Daily precipitation and*

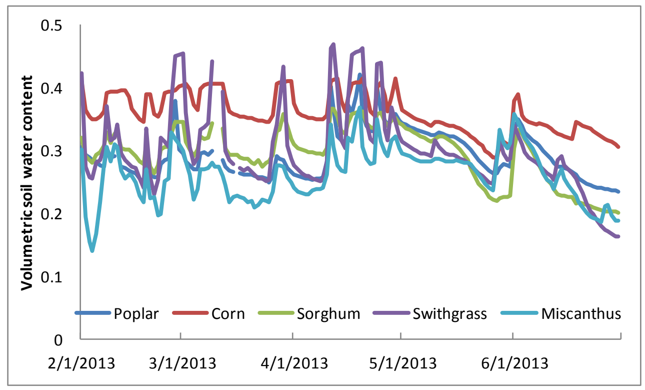

Fig.2. *Soil moisture at a depth of 30*

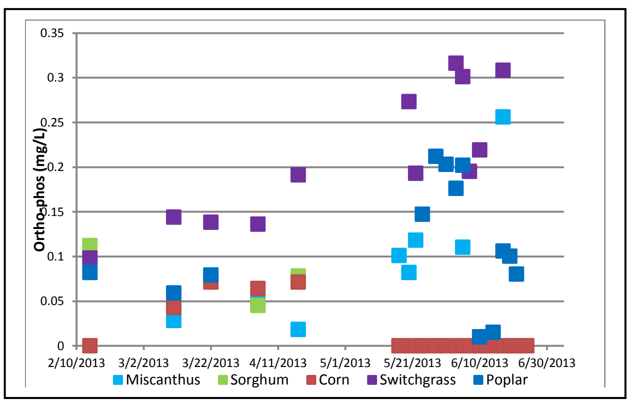

Fig.3. *In field ortho-phosphorus, central lysimeter*

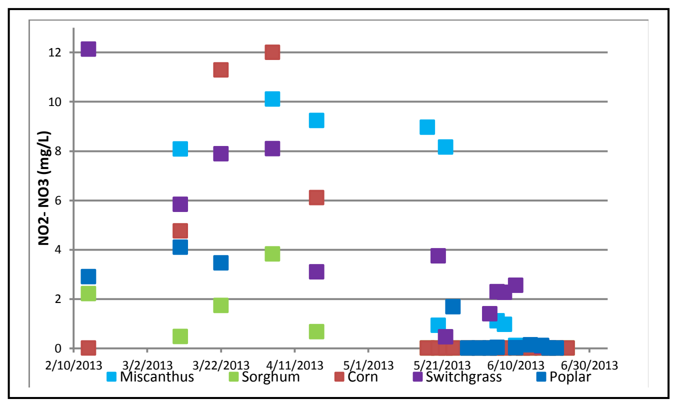

Fig.4. *In field nitrate data, central lysimeter*

NEXT STEPS

1. Continued data collection
   - ➢ Surface runoff from all plots
   - ➢ Soil samples for physical property analysis
   - ➢ Biomass estimates in the fall
2. Data Analysis
   - ➢ Statistical analysis to identify correlations between variables.
   - ➢ Use of observational data to parameterize plot and watershed scale models.

CONTACT INFORMATION

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RESPONSE TO SWITCHGRASS TO N, P, AND K ON MARGINAL LANDS

R. Dierking, *S. Cunningham, P. Woodson, S. Brouder, J. Volenec*

Purdue University / Agronomy Department

OBJECTIVES

The goal of these projects (TPAC I and II) is to identify the role N, P, and K have on the yield response of switchgrass grown on marginal sites (soils with inherently low P and K). Additionally, we aim to identify the role these nutrients play on tissue N, C, P and K concentrations, and structural and non-structural carbohydrate composition.

IMPACT

- Gain an understanding how switchgrass yield and composition respond to fertilization on low fertility soils.
- Determine critical soil test and tissue concentration levels for N, P, and K and understand nutrient use efficiency of switchgrass.
- Determine theoretical ethanol and bio-oil yields under various management scenarios.

APPROACH

- The plots are located in west central Indiana, USA at the Throckmorton Purdue Agricultural Center (TPAC).
- The plots are overlaid on soils with variable concentrations of extractable P (5-60 mg kg^{-1}) and exchangeable K (60-270 mg kg^{-1}).
- Upland switchgrass ecotype 'Shawnee' was planted in May 2007.
- Treatments were blocked into four reps with historic P rates (0, 25, 50, and 75 kg ha^{-1}) and K rates (0, 100, 200, 300, 400 kg ha^{-1}) on TPAC I. Historic P rates (0 and 75 kg ha^{-1}) and K rates (0 and 400 kg ha^{-1}) were split with N rates (0, 50, 100, and 150 kg ha-1) on TPAC II.
- N-fertilization commenced the second year with the rate of 84 kg ha^{-1} y^{-1} in May as Agrotain™-treated urea (TPAC I).
- The harvested area was 1 x 10m through the center of each plot.
- Harvested material was used to determine biomass yields, N, C, P, K, neutral and acid detergent-fiber, lignin, and total ash.

KEY FINDINGS

- No effect of N, P, and K fertilization on biomass yields.
- Soil P/K concentrations correlate well with tissue P/K concentrations.
- Potassium tissue concentrations are lower compared to companion studies with *Miscanthus* (2.6 vs. 4.3 mg g^{-1}).
- Switchgrass yields were reduced 23% by drought conditions in 2012.
- Hemicellulose, cellulose, lignin, and ash concentrations averaged 308, 345, 79, and 42 g kg^{-1}, respectively, and were not altered by P/K.
- Sugar and starch concentrations averaged 12 and 5.6 g kg^{-1}, respectively.

Currently, there is limited research on bioenergy-crop production on marginal soils, with biomass-production potential of these different landscapes being largely unknown. Additionally, information on nutrient cycling of candidate biomass systems is incomplete across much of the marginal sites.

RESULTS & PRELIMINARY DATA

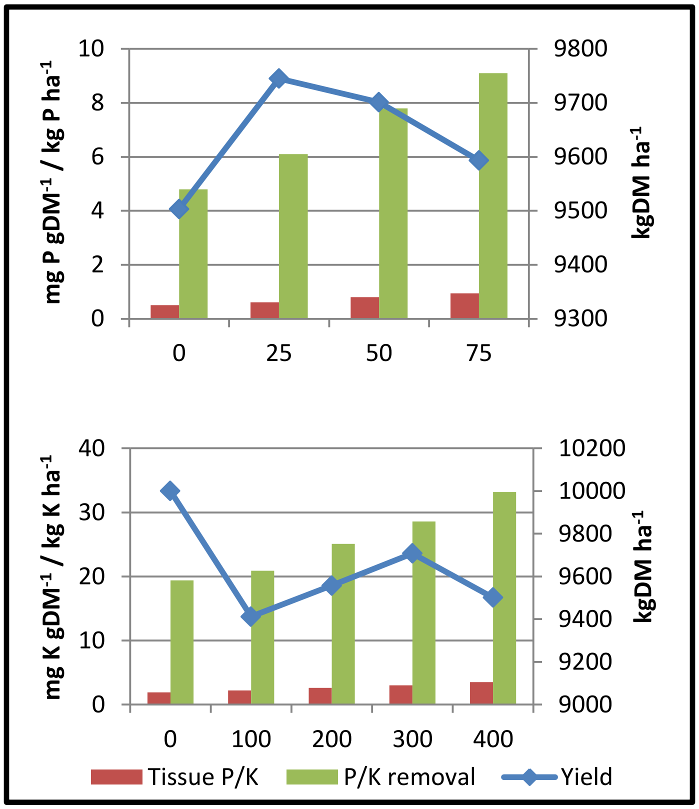

Fig.1. *Yield responses (line), P/K tissue (red bar), and P/K removal (green bar) for TPAC I historical*

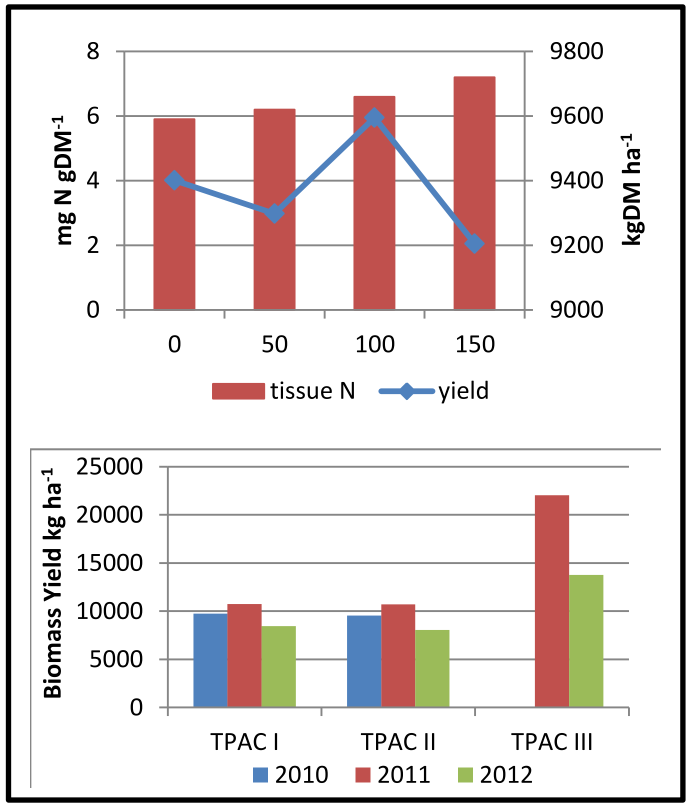

Fig.2. *Yield responses (line), N tissue (red bar) for TPAC II (top). Yield changes across years (bottom)*

NEXT STEPS

- Identify long-term impacts of fertilization regimes on yield, persistence, and composition of switchgrass.
- Establish fertilization recommendations based on soil and tissue tests since little is known about P and K needs of switchgrass for biomass production.

PUBLICATIONS / PRESENTATIONS

1. P. Woodson, J.J. Volenec, and S.M. Brouder. 2013. Field-scale potassium and phosphorus fluxes in the bioenergy crop switchgrass: Theoretical energy yields and management implications. J. Plant Nutr. Soil Sci. 176:387–399.

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RESPONSE OF *MISCANTHUS* x. *GIGANTEUS* TO N, P, AND K ON MARGINAL LANDS

Ryan Dierking*, S. Cunningham, S. Brouder, J. Volenec*

Purdue University / Agronomy Department

OBJECTIVES

The goal of these projects is to identify the role N, P, and K have on the yield response of *Miscanthus giganteus* grown on marginal sites (soils with inherently low P and K or coarse-textured soils). Additionally, we aim to identify the role these nutrients play on tissue N, C, P and K concentrations, and structural and non-structural carbohydrate composition.

IMPACT

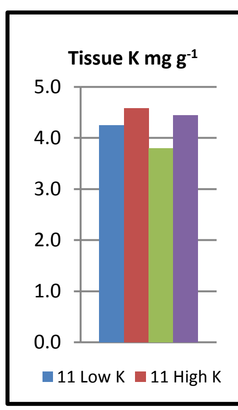
- Identify cultural practices necessary to maintain soil fertility and high production biomass.
- Ascertain the range of components (i.e. fiber and minerals) and their impact on ethanol or bio-oil generation.

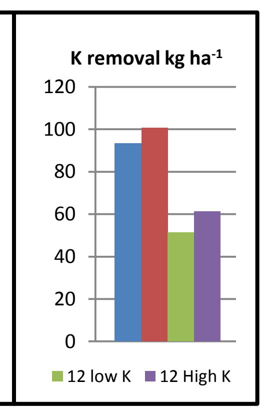
APPROACH

- The plots are located in west central Indiana, USA at the Throckmorton Purdue Agricultural Center (TPAC) and Buck Creek, IN.
- The TPAC plots are overlaid on soils with variable concentrations of extractable P (4-67 mg kg^{-1}) and exchangeable K (100-640 mg kg^{-1}).
- At TPAC Miscanthus x giganteus was transplanted on 1m centers in June 2009. Treatments at TPAC were blocked into four reps with N rates (0, 50, 100, 150 kg ha^{-1}) as main plots and P/K rates (0/0, 30/300 kg ha^{-1}) as subplots.
- At Buck Creek four genotypes were planted in 2009. These were fertilized in 2010 with 0, 50, 75, 100, or 150 kg ha^{-1}. In 2011 the treatments were 0-0, 0-150, 50-100, 75-75, 100-50, 150-0, and 150-150 kg ha^{-1}.

KEY FINDINGS

- N increased yields of *Miscanthus* grown on coarse soils by 28%.
- P and K fertilization did not alter biomass yields.
- Potassium tissue concentrations are considerably higher (2-3x) compared to companion switchgrass plots.
- Drought conditions in 2012 reduced *Miscanthus* yields by 38%.
- Hemicellulose, cellulose, lignin and ash concentrations averaged 291, 387, 89, and 40 g kg^{-1}, respectively, and were not altered by fertility.
- Sugar and starch concentrations averaged 25.7 and 8.9 g kg^{-1}.





***To date Miscanthus* x. *giganteus* yield response to N-fertilization has been low, and inconsistent. However, work from one of our marginal sites indicates that *Miscanthus* does in fact respond to N fertilization when grown on coarse soils.**

RESULTS & PRELIMINARY DATA

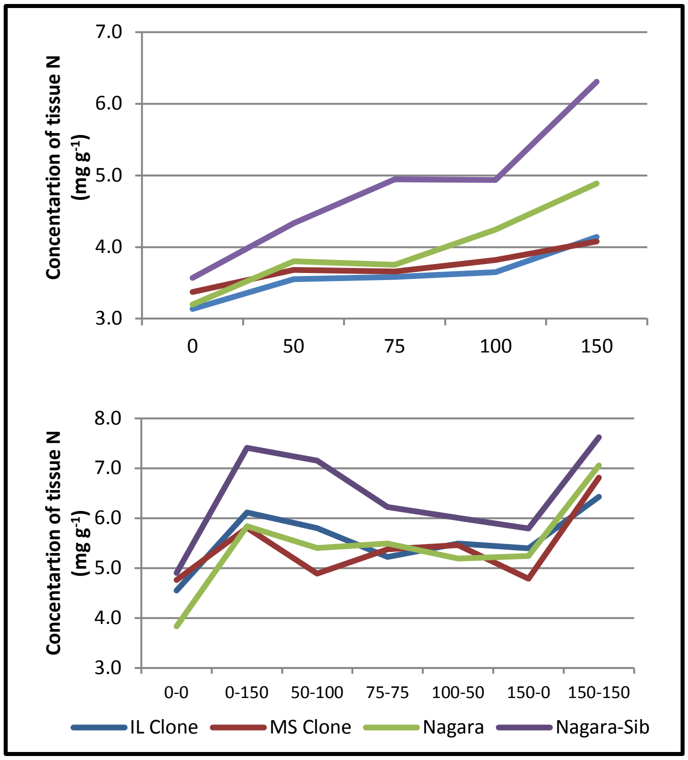


Fig.1. *Concentration of tissue N in four genotypes of Miscanthus in 2011 (top) and 2012 (bottom) with varying levels of N-fertilization.*

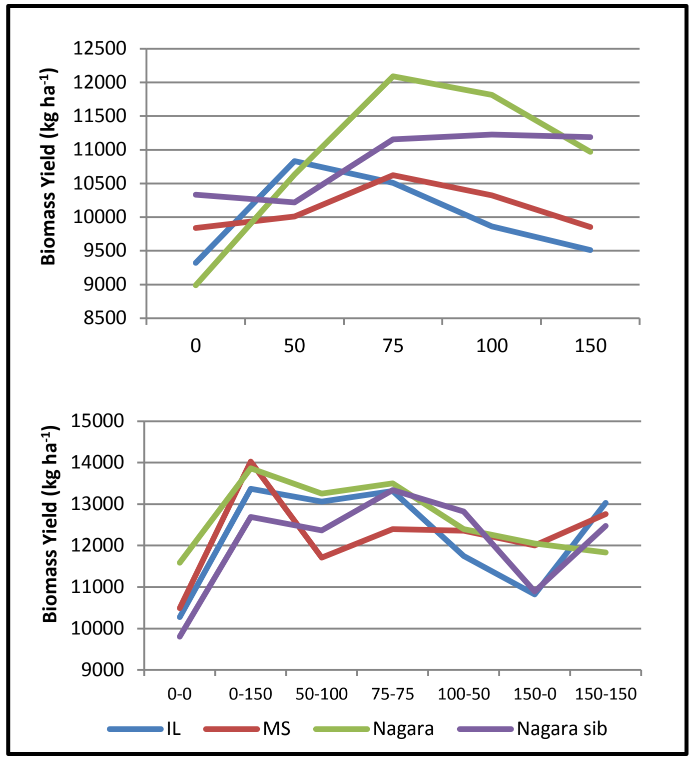


Fig.2. *Biomass yield of four genotypes of Miscanthus in 2011 (top) and 2012 (bottom) with varying levels of N-fertilization.*

NEXT STEPS

- Evaluate the belowground tissues (rhizomes and roots) and stem bases for C and N pools, including proteins and amino N, and relate these to yield and persistence of these *Miscanthus* lines.
- Use tissue and soil test results to identify critical levels and long-term trends of fertilization regimes on established *Miscanthus* stands.

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BIOMASS YIELD AND COMPOSITION OF SORGHUM AS A POTENTIAL BIOFUEL FEEDSTOCK: PRODUCTIVITY POTENTIAL ON MARGINAL LANDS

***Monique K. Long**, Sylvie Brouder, and Jeff Volenec*

Purdue University, Ecological Sciences and Engineering Interdisciplinary Graduate Program; Department of Agronomy

OBJECTIVES

1. To evaluate the agronomic performance of sorghum lines for potential biofuel use in comparison to maize on marginal lands.

2. To determine the impact of nitrogen (N) application rates on yield and tissue biomass composition significant in ethanol bioconversion.

IMPACT

Why Sorghum?

Sorghum is known for its high water and nitrogen use efficiency. Its vast genetic variation has also allowed it to be a great target for breeding for biomass for bioenergy; given that sorghum is an annual crop in the humid Midwest, corn and soybean farmers can easily adapt to its production requirements.

Why Marginal Lands?

In a 2008-2010 study at ACRE, sorghum exhibit several biomass production advantages on prime agricultural soils. If sorghum is able to maintain high yields on sites marginal for maize production the co-benefit of biomass production without competing with food/feed crops like maize could be realized.

APPROACH

Beginning in 2011, the 5 year research project on marginal lands has been conducted at 3 Purdue Agriculture Centers – (North to South transect) (Fig. 1), allowing for 15 different site-year environments. Five N-application rates were applied to 3 sorghum genotypes and maize.

- Marginal Sites
  - History of very low maize and soybean yields.
  - NePAC – Highly Erodible; sandy/gravelly; steep slopes; low temps.
  - SePAC – poorly drained; excessively wet; soil cap over old trash dump.
  - TPAC – P and K deficient; low pH; high water table; erosion prone; low soil organic matter
- Three sorghum lines & hybrid maize (control)
  - Photoperiod-sensitive; Sweet; Dual-purpose;
- Five N Application Rates
  - 0, 50, 100,150, 200 (kg ha $^{-1}$)
- Analyses
  - Hand harvested at maturity
  - TNC- Sugars and Starches
  - Fiber - NDF, ADF, ADL, Ash
    – cellulose, hemicellulose and lignin
  - Other nutrients
    – C, P, K

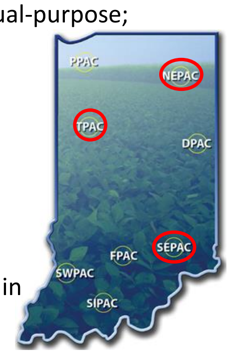

Fig 1. Purdue Marginal Sites

KEY FINDINGS

- The above ground biomass yields varied with environment and N rate, and sorghum genotype.
- The biomass yields of photoperiod-sensitive sorghum and sweet sorghum were consistently higher than maize on marginal lands.
- Sorghum outperformed maize especially in years of drought (Fig 2).
- Tissue composition relevant to bioenergy production varied among genotypes.
- Benefits of plant composition will be dependent on bioconversion requirements and pathways (biochemical vs. thermochemical).

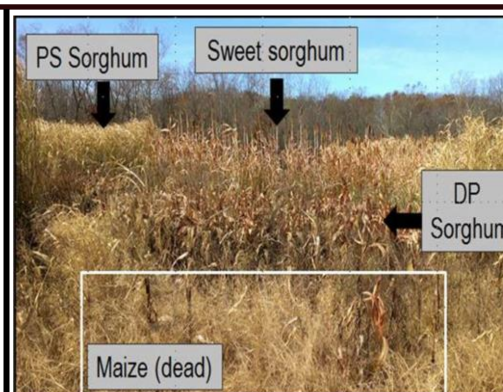

Fig 2. SePAC 2012 at time of harvest

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Sorghum is a great crop, easily adapted into current production rotations and is a top performer on marginal lands in Midwest, USA. We need to better understand the feasibility and sustainability of producing sorghum for biofuels in this region; a good starting point is to understand the effects of genotype by nutrient mgmt. by environment effects on sorghum on these lands.

RESULTS & PRELIMINARY DATA

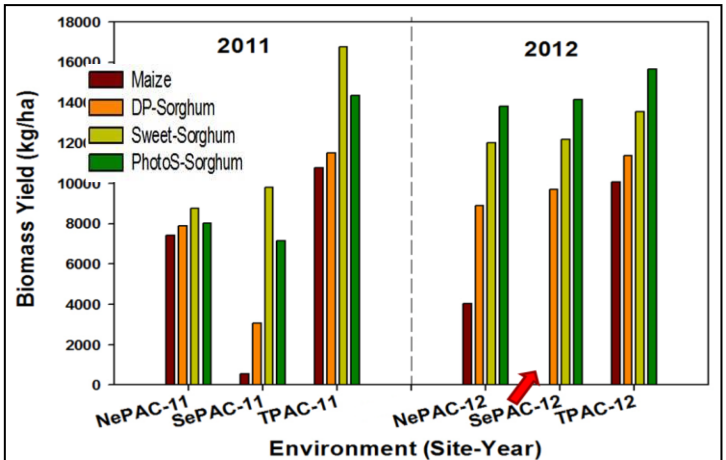

Fig 3. *In 2011-12 sorghum yields were higher than maize on marginal lands. At SePAC' 12, all 3 sorghum genotypes had average yields; maize produced none (arrow).*

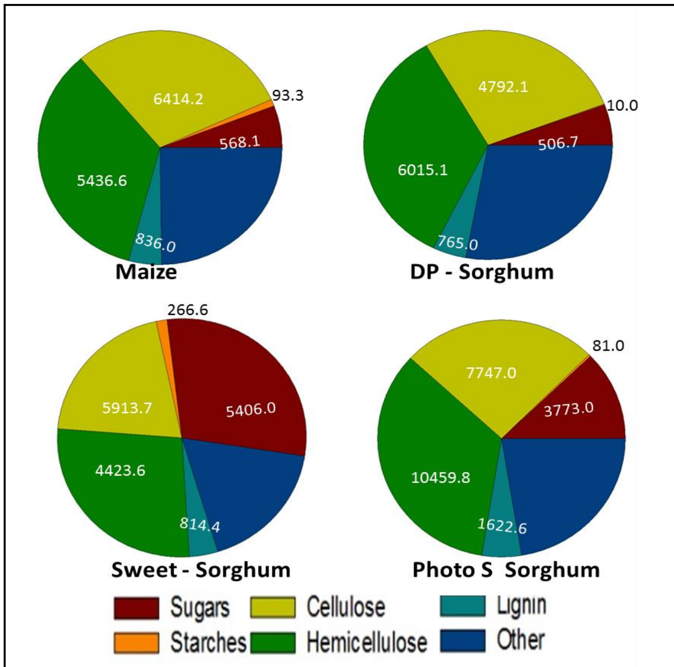

Fig 4. *In 2008 ACRE, the stover tissue composition is similar in maize (top-L), dual purpose sorghum (top-R), but is different among Photo S sorghum (right) and sweet sorghum (bottom-L) genotypes.*

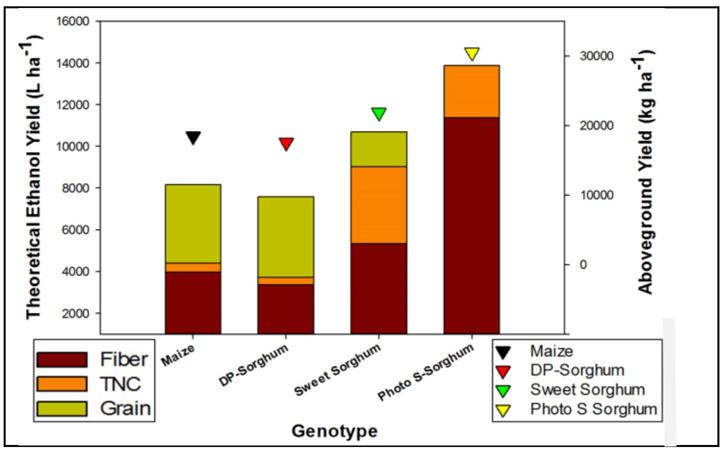

Fig 5. *In 2008 the calculated theoretical ethanol yields demonstrate that variation in biomass composition will impact ethanol yield per ha.*

NEXT STEPS

- Evaluate theoretical ethanol yield for all sites.
- Assess internal efficiencies (NUE agronomical and WUE) of sorghum genotypes
- Collaborate with sorghum breeding programs to define ideal traits for biomass for bioenergy.
- Determine agronomic and economic optimum N rate for fertilizer to ethanol price ratios.

PUBLICATIONS / PRESENTATIONS

- Long MK, S Jones, L Rivera, J Volenec, and S Brouder. Nitrogen impacts on the cell wall composition of sorghum lines used for biomass. ESE-IGP Annual Symposium in West Lafayette, IN. Nov 2011.
- Long MK, J Volenec, and S Brouder. Nitrogen Impacts on the yield and composition of contrasting sorghum lines used for biofuels. 2012. ASA, CSSA &SSSA International Annual Meetings in Cincinnati, OH. Oct 2012.

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EVALUATING SWITCHGRASS, BIG BLUESTEM AND INDIANGRASS SELECTIONS FOR THEIR ADAPTATION, PRODUCTIVITY AND COMPOSITION

Keith D. Johnson

Purdue University/Agronomy Department

OBJECTIVE

The objective of this research is to contribute one of many datasets from across the North Central USA region that will determine differences among switchgrass, big bluestem and indiangrass selections for their adaptation, productivity and composition when used as potential sources of bioenergy.

IMPACT

Productivity and composition differences among the different grass selections will determine whether these specific selections have possible utility for energy purposes.

APPROACH

- Field research at the Throckmorton- Purdue Agricultural Center; located several miles north of Romney, IN
- Separate studies for each grass species
- Randomized Complete Block Design; four replications
- Established in the spring of 2012
- Stand counts taken mid-spring 2013
- Heading dates being recorded
- Harvest will occur mid-autumn

KEY FINDINGS and OBSERVATIONS

- The severe drought of 2012 did impact seedlings and weed control with herbicides.
- Seed quality could have been a factor with many selections.
- Indiangrass had best early season visual appraisal of stand.
- Major differences in establishment occurred as verified by stand count.
- Removal of plant growth in the fall as a means to remove weedy growth could have impacted some selections ability to survive winter.

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NOTES

NOTES

Exhibit 7

2013 CenUSA Bioenergy Annual Meeting Evaluation
July 30 - Aug. 2, 2013
Purdue University
26 Total Evaluations

A. Annual Meeting 2013

1. **The meeting covered all the project objectives clearly.**
2. **The meeting format was conductive to learning what other teams were doing.**
3. **There was enough time to network with project colleagues.**
4. **The field tours were valuable in helping me better understand Objective 2.**

	Strongly Agree		Agree		Disagree		Strongly Disagree		Not Applicable		Total Response	
1	17	65%	9	35%	0	0%	0	0%	0	0%	26	100%
2	12	46%	12	46%	2	8%	0	0%	0	0%	26	100%
3	10	38%	13	50%	3	12%	0	0%	0	0%	26	100%
4	11	42%	11	42%	0	0%	0	0%	4	15%	26	100%

5. **If you participated in last year's Annual Meeting in Lincoln, Nebraska (August 2012), how was the meeting beneficial in helping your team accomplish its objectives for the 2nd year?**
   - Being able to talk face to face for an hour or more on several occasions- lunch, dinner, group meet up
   - Just getting together goes a long way throughout the year in helping us work as a team. I also think just acquiring the understanding of the other objectives is important to do a better job
   - Understanding the agronomic requirements and yields for calculation for itsr costs
   - Better understanding of project objectives and their importance in meeting the cenUSA objectives. Better understanding of each team member note.
   - It is important to learn the progress of the project and to form new goals
   - More focused, Thank you
   - I think the meeting was very beneficial especially learning about the status of crop development and outreach plans. Commercialization strategy really needs to be thought about
   - I guess seeing the plots was the most useful part of it, but it was all useful.
   - Seeing the test plots, difference in plant size, nutrient loss analysis was very interesting to me – Advisory board comment
   - It is valuable for the extension team to interact with the researchers to know what they are doing and how it can be used in extension.
   - Understanding of larger project. Contacts with other collaborators enabled bridging across teams.
   - It's always good to see our objective collaborators in person to "gel" our ongoing work.
   - It is very beneficial and helps build teamwork to have these annual meetings. We get much more accomplished in a shorter amount of time when we meet face-to-face. Please continue having these meetings each year. We are also including subsequent F2F meetings as the Extension Master Gardener team as well during the year.

- It was valuable for the team members to meet face to face. There is no substitute for meeting and discussing.
- What everyone was working on. We need these contacts and this information to help us develop extension and education materials.
- Was not able to attend last year.

6. **What barriers have you encountered in reaching your team's objectives for the 2nd year?**
   - Occasionally- long distance communication with partners. Getting good students hired to get 'things' moving.
   - Just time! Like many, I am stretched in all I do for time to do it.
   - Reporting requirements! I spend way too much of the time I allocate to this PN; etc reporting on activities
   - Personal requirement
   - Weather – time
   - Short time frame, weird weather challenge
   - Not on a team/advisory board
   - As I started working in the project's second year – took a while to get up to speed
   - It has often been difficult to get the attention of project collaborators in other objectives to produce work together. Seems we're all stretched so thin…
   - Non that I can think of. Weather has probably been the biggest hurdle as far as our demo gardens go, but it has not affected our grant deliverables.
   - The primary barrier has been time to complete items and the distance between collaborators.
   - The review process has been slow, both for CenUSA and Extension. CenUSA researchers and collaborators are very busy people which makes it difficult to get content review completed in a timely fashion
   - The complexity of the analysis and the fact that it has not been accomplished/published in agriculture before has introduced some unexpected delays but we'll power forward.

B. Administrative Support

7. **Administrative support during the past year has been helpful.**
8. **Administrative responses to my questions/concerns were handled quickly.**
9. **Budget requests were handled in a timely manner.**
10. **Budget issues were resolved to my satisfaction.**
11. **Online meeting have been useful in settling issues related to my responsibilities.**

	Strongly Agree		Agree		Disagree		Strongly Disagree		Not Applicable		Total Response	
7	13	54%	9	38%	0	0%	0	0%	2	8%	24	92%
8	17	71%	4	17%	0	0%	0	0%	3	13%	24	92%
9	5	21%	3	13%	0	0%	0	0%	16	67%	24	92%
10	5	21%	3	13%	0	0%	0	0%	16	67%	24	92%
11	7	29%	6	25%	0	0%	0	0%	11	46%	24	92%

12. **What might have project administration done during the past year that would have helped you meet your team's objectives for the 2nd year?**

- Nothing I can think of! Admin does a GREAT JOB!
- Push for more product
- Great job, help special meeting with me to explain the grant, etc.
- Continue to stay in contact and communicate the status and progress of our objective.
- Nothing I can think of. They are responsive, helpful and clear in what they need from us. They also are respectful of our time and efforts.
- The administrative staff has done a great job. I appreciate the way Anne and Val do business.
- I have been satisfied with administration's assistance when needed. Typically we just need a little help encouraging reviewers to get back to us on objectives 8 and 9 content.
- The project administration is wonderful. Have enjoyed and continue to enjoy working with them. They have been understanding and very supportive during the entire process.

13. What do you anticipate needing from administration for the coming year?

- A Manned Poster session of all students/post docs on project at next meeting. Even could include faculty. Way to learn about all aspects – can't always get whole picture in 1 hour presentations.
- Many of the same thing already provided
- More push!
- Communication on how research is progressing, etc.
- More of the same. Positive reinforcement is always nice.
- Maybe proactively work to match up "our" objective with others where there are synergies (one at a time); how about every 2 or 3 months having a cross-objective meeting.
- 6 months from now having an all collaborators online meeting – maybe each objective could highlight one thing they've worked on (excited about +/or struggling with) to get feedback
- Just more of the same!
- Support, guidance and forgiveness
- I anticipate needing occasional help tracking down reviewers, and encouragement for other objectives to help us create materials. So far though, almost all individuals we have contacted to help us create these materials have been very responsive and helpful.
- The follow up reminders were helpful last year and I am sure they will continue to be helpful. Some assistance with budgeting might be useful because it seems like object is just a bit off cycle.

14. Additional comments:

- Prior to meeting (when agenda came out) we knew the meeting was scheduled too long. Never needed Friday Morning! Please plan accordingly next year, small groups could meet over meals. Did a great job with dietary needs.
- Internet access at meeting sites should be excellent. It was not at Ag ctn. We should establish social media parameters for each meeting Ex: Twitter hash tag so we can tweet about the meeting during the meeting
- I'm not sure this is all in our control, but anything to reduce time spent reporting would be great. I allocate 1 month to this project, and nearly all of that is consumed in meetings and reporting. It seems an inefficient use of valuable time.
- This is my first year with CenUSA
- Have advisors speak before breakfast sessions

- Lighting during the presentations and distance from the screen was difficult. I think moving farther back would allow the speaker to engage the audience rather than only seeing the screen.
- Thanks for a good meeting- very informative.
- CenUSA needs to focus more attention to the benefits of perennial grass establishment regarding the impact of soil and water conservation
- Conference could be scheduled for a shorter period of time if events were more condensed
- The team needs to brainstorm what needs to be done to develop a commercialization strategy including developing other initial markets and enabling startups in pyrolysis. I also think with all the information on biomass crops in general the extension team should put together a portfolio of information on opportunities, which crop to plant when and where to look for markets.
- Thanks and looking forward to another great meeting next year in MN!
- Thank you for re-arranging the schedule allowing me to travel home Thursday. Your team does an amazing job organizing the event and always fun to travel to farm. See you for harvesting next year!
- Re: this 2013 annual meeting: I was very disappointed, feeling that it didn't make the best use of the valuable (and expensive!) time when we are all in the same place. Way too much "being talked at" and not enough time to really interact within our own objective, or for our objective to find the common working territory with other objectives. Our Extension team breakout was very good, but felt we could have used more work time together.
- Ideas for future annual meeting:
    - Public show and tell (maybe a ½ day or evening), where stakeholders are invited – some kind of symposium that furthers our topic while teaching something from each objective. Include stakeholders in working team sessions if it is pertinent
    - If same style as '13, 15 min of team overview would be *plenty*. While I'm interested in all other teams work, what they know and how I might work with them, I am not interested in a dry rundown of accomplishments that I could read in a report instead.
    - Breakout sessions allowing team crossover – 2+ objective teams working together.
    - Facilitated discussion on pertinent topics
        - Make discussion more fruitful with better use of mics and better facilitation – I often couldn't hear questions and comments. Maybe find 4-H'ers who could run the mics around (? – it works great at our town meetings – kids hustle and have some fun with it)
        - Advisory Panel and NIFA comments were valuable (though I noted some contradictions worthy of exploration), and I'd like to see it as more than a bookend to the meeting. Their input could have led to a wider, deeper conversation had there been time.
- Jeff, Anne, and Val did a great job with the annual meeting. The arrangements were superb.
- Selfishly, I would like to see the larger objectives have more time to present at the meeting next year. In Objective 2, we have so many sites and scales that 45 minutes is limiting our ability to represent the body of work.
- Ken Moore's leadership has been excellent. He has done an outstanding job of representing the project.
- Next year I think it would be useful to shorten presentations and allow for additional break out time for teams from different objectives to meet. This would encourage collaboration. I

appreciate that the conference was shortened by half a day. Thanks too for providing plenty of healthy food options at all meals and snacks.

- Enjoyed the time at the conference. Believe the group to be an exceptional one. Glad to be part of the CenUSA project.

Exhibit 8

IOWA STATE UNIVERSITY
Bioeconomy Institute

Roadmap to Commercialize Thermochemical Biofuels and Bio-products Processing in the Midwest Workshop

Dates: December 11-12, 2012
Sponsors: ISU Bioeconomy Institute, CenUSA Bioenergy, USDA Central-East Regional Biomass Research Center, Iowa EPSCoR, Iowa Energy Center*
Location: Scheman Center, Iowa State University

December 11		
Time	**Subject**	**Presenter(s)**
11:30 am	**Registration and Lunch**	
12:15 pm	**Welcome**	• Wendy Wintersteen, Iowa State University • Jonathan Wickert, Iowa State University • Ken Moore, Iowa State University
12:30 pm	**Sustainability Challenges to Biofuels**	Byron Johnson, P66
1:00 pm	**Thermochemical Conversion Technologies 101**	Robert Brown, Iowa State University
1:30 pm	**Impacts of Facility Scale and Location on Thermochemical Biorefinery Costs**	Mark Wright, Iowa State University
2:00	**Break**	
2:15 pm	**Ideal Feedstock Characteristics for Thermochemical Processing of Biomass** • Pyrolysis • Acetic Acid Pulping • Solvent Liquefaction • Catalytic Pyrolysis • Gasification • Pyrolysis • Pyrolysis • Aqueous Phase Reforming & Catalytic Processing • Solvent Liquefaction	• Mark Hughes, P66 • Tom Binder, ADM • Michelle Young, Chevron • Magdalena Ramirez, KiOR • Bert Bennett, ICM • Terry Marker, GTI • Stanley Frey, UOP • Andrew Held, Virent • Manuk Colakyan, Renmatix
3:45 pm	**Q and A**	
4:00 pm	**Break**	
4:15 pm	**CenUSA USDA NIFA Bioenergy CAP Project** Preparing the Midwest to Supply biomass Feedstocks for Thermochemical Processing	Ken Moore, Iowa State University

4:45 pm	**Optimizing Plant Breeding, Agronomy, and Logistics for Thermochemical Processing** • Perennial Grass Genetics • Perennial Grass Storage and Agronomics • Environmental and Genetic Bioenergy Traits in Corn Stover • Corn Stover Genetics • Corn Stover Agronomics	• Ken Vogel, USDA ARS, Lincoln, NE • Rob Mitchell, USDA ARS, Lincoln, NE • Kendall Lamkey, Iowa State University • Thomas Lubberstedt, Iowa State University • Marty Schmer, USDA ARS, Lincoln, NE
5:45 pm	**Q and A**	
6:15 pm	**Adjourn to ISU BioCentury Research Farm**	Transportation provided
6:30 pm	**Dinner**	
7:15 pm	**Tour**	• Andy Suby, ISU, Overview • Stuart Birrell, ISU, Logistics • Robert Brown, ISU, Thermo Processing
7:45 pm	**Dessert Buffet and Discussion**	
8:15 pm	**Adjourn** Transportation to Scheman Parking Lot	Shuttle to Hotel

December 12

Time	Subject	Presenter(s)
7:30 am	Breakfast	
8:00 am	**Non-fuel Products from Thermochemical Processing** • Heating Oil (30 min) • Biochar as a Soil Amendment (20 min) • Bioasphalt (20 min)	• Prasad Gupte, DOE • David Laird, Iowa State University • Chris Williams, Iowa State University
9:15 am	Establishing Linkages Between Thermochemical Biorefiners and Midwest Biomass Feedstock Suppliers	• Brad Petersburg & Rusty Schmidt, Ag Ventures Alliance • Rod Backhaus & Howard Roe, Tall Corn Ethanol • Bill Couser, Lincolnway Energy • Paul Kenney, Kearney Area Ag Producers Alliance • Jeff Stroburg, West Central Coop • Rod Williamson, Iowa Corn Producer Assoc.
10:30 am	**Q and A**	
10:45 am	**Break**	
11:00 am	**Assembling the Pieces to Commercialize Thermochemical Processing in the Midwest**	All
12:00 pm	**Lunch - Discussion Continues**	
1:00 pm	**Adjourn**	

*Workshop support: Iowa State University Bioeconomy Institute; CenUSA Bioenergy, funded by USDA-Agriculture & Food Research Initiative Competitive Grant no. 2011-68005-30411 from USDA National Institute of Food & Agriculture ; Iowa EPSCoR, supported by the National Science Foundation under Grant Number EPS-1101284; & Iowa Energy Center. We also thank Ken Vogel, ARS for his assistance in developing this event.

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Roadmap to Commercialize Thermochemical Biofuels and
Bioproducts Processing in the Midwest Workshop

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Exhibit 9

CenUSA Roadmap to Commercialize Thermochemical Biofuels and Bio-products Processing in the Midwest Workshop

Question: What specific action items would you recommend to speed commercialization of thermochemical processing in Midwest?

Recommendations

Feedstock Development/Logistics

- Vertical integration that identifies the specifics of the processes that need improvement.
- Focus on high value products that will allow the supply chain to develop/be understood.
- Education and communication between producers and industry so risks are understood and options can be developed to address risks.
- Create consortium, multi-industry, develop shared vision, R & D, etc. To be widely engaging of supply chain, stakeholders, and geographically diverse.

Logistics

- Solve the feedstock supply chain for first plants
  - Densification?
  - Stabilization?
- Improve communication among stakeholders to build supply chains.

Conversion

- More R & D, demo plants with funding partnerships including government and industry.
- Long-term pre-commercial technology demonstrations of successful conversion.

Public & Policy Support

- Long-term stable government policy.
- Develop policy, business climate and financial structures for construction of initial plants;
  - Incentives?

CenUSA Bioenergy is supported by Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30411 from the USDA National Institute of Food and Agriculture. More information is available at www.cenusa.iastate.edu

    - State, region vs. national

- Develop regional strategy for thermochemical biofuels.
- Replace legislative uncertainty with national commitment.
- Long-term, stable renewable fuels policy (State and Federal).

Reactions to Recommendations: already working on

Feedstock Development

- Bryan Mellage – C-Minus
    - Bring value to by-product of thermochemical processing – biochar.
    - We will buy and sell biochar as carbon sequestration.
- USDA-ARS
    - Working to develop perennial grasses that yield 10 T/Acre.
- Iowa State University (Agronomy)
    - Develop sustainable biomass supply management systems
- Tom Binder – ADM
    - Developing pilot plant to take multiple feedstocks to value added products as well as fuels.
        - Hopefully successful without subsidies
    - We have worked with Monsanto, Deere, and consumer product companies to address value chain.
- USDA-ARS
    - Developing new improved varieties of feedstocks.
    - Developing sustainable production systems.
    - Developing tools to predict impact on ecosystem services.
- Iowa Corn Growers Association
    - We are supporting maintaining the RFS.

- We are funding research on thermochemical conversion to high value products.
- We are participating in research and meetings on feedstock harvest storage and transport.

- Jeff Volenec – Purdue – CenUSA
  - We are conducting research and education programs that will inform the production capabilities and environmental sustainability metrics of a wide range of biomass production systems. This information is needed for LCA, economic analysis, regulatory analysis, etc.
- USDA-ARS
  - Feedstock development
  - Feedstock production and logistics
  - Fuelshed-scale site selection for feedstock production
- Iowa State University (Extension)
  - Education potential producers and industry leaders on biomass production.
- UOP/Envergent
  - Advise on/work with feedstock requirements/constraints with the growers here in the Midwest.

FEEDSTOCK & LOGISTICS

- Chevron
  - Working with universities to better understand supply/logistics
- USDA-ARS (multi-locations and scientists)
  - Feedstock development
  - Feedstock quality
  - Feedstock quality assessment
  - Feedstock storage
  - Feedstock conversion

- Producer technology transfer
- Sustainability

Logistics

- BP
  - Working with government and private industry to bring demo plants and other R & D on-line.
- USDA-ARS (multi-locations)
  - Provide feedstocks for testing – multi-types
  - CRADA's and other technology assistance

Logistics/Conversion

- West Central
  - Develop a commercial scale model for collecting and storing biomass. (Prospective)
- UOP/Honeywell
  - Improve communications among stakeholders and build supply chains
  - We are in the petroleum business, but not operators. We are also in the renewables business. We have had to bring biorenewable feedstock suppliers together with fuels producers in the past to get projects to go.
- Iowa State University
  - Research on feedstock logistics
  - Research on thermochemical conversion
  - Research on sustainability
- Conversion
- Iowa State University (Agronomy)
  - Develop value added biochar technology
- Iowa State University

- R & D on thermochemical conversion

- Renmatix
  - Adopting our technology to process several of the feedstock discussed in the workshop.
- UOP/Honeywell
  - Building 1 tpd pilot plant to convert lignocellulosic biomass to gasoline and distillate fuels at Tesoro petroleum refinery in Hawaii.
- Andrew Held – Virent
  - Reduce technology risk and demonstrate cost performance such that strategic partners will invest and build production facilities.
- Chevron
  - Might build a demo unit to illustrate how different entities need to work together.
- Ag Ventures Alliance
  - We invested $250K in Avello.
- Tom Binder – ADM
  - We are looking into conversions of hemicellulosic and lignin into multiple value added products and are able to interest large chemical companies.
- Iowa Energy Center
  - R & D/Pre-commercial and conversion technology development/demonstrations

WORKFORCE DEVELOPMENT/PUBLIC & POLICY SUPPORT

- West Central/REG
  - Have a dedicated staff working educating and advocating for stable public policy particularly as it related to RFS2.
- Iowa State University
  - ISU has several centers working on bioenergy related policy.

PUBLIC & POLICY SUPPORT/OTHER

- UOP/Envergent Technologies
  - Involvement in DOE projects to demonstrate the viability and economics of our process to further influence the adoption of policies that support its implementation.
- Farm Bureau
  - Already has policy that supports the continued development of renewable energy.

OTHER

- USDA-NIFA
  - Funding CenUSA
  - Provide post-award management support to facilitate a broadening consortium developing a shared vision among stakeholders across the entire supply chain and communities impacted by the development of regional systems.
  - Provide supplemental funding
    - Provide new funding for knowledge gaps identified
- Brad Petersburg – RDA & RDP
  - Using new markets tax credits to help finance the commercialization of one or more biorefineries in low-income communities.
- CenUSA
  - All areas with collaboration from USDA and industry partners.
- KiOR
  - Impact - Starting up commercial unit, results will affect the way stakeholders react in the future.
  - Positioning – Clear and focused strategy and development of IP platform.

REACTIONS TO RECOMMENDATIONS: POSITIONED TO ADDRESS

FEEDSTOCK DEVELOPMENT

- Iowa State University (Extension)

- Demonstrating to potential producers convincing risk management strategies to biomass production.

- Brad Petersburg – RDA and AgVA
  - Form producer groups to supply biomass and invest in biorefineries
- Iowa Corn Growers Association
  - Collaborate with companies that have thermochemical technology on research, demonstration, and supply chain.
  - Educate corn growers about future opportunities for markets for corn stover.
- Jeff Volenec (Purdue/CenUSA)
  - Initiate new research as needed – identified by stakeholders, to inform critical questions.
  - Participate in leadership/consortium of stakeholders discussions to move things forward.
- Bryan Mellage (SEN Energy)
  - Organize producers in Southeast Nebraska to get ready to bring a thermochemical plant to our area.
- USDA-ARS
  - May be able to reduce need for N fertilizer on perennial grasses.
- Unknown
  - Energy Grains – USDA grant to organize farmers to plant relationships that bring all into one.

FEEDSTOCK/LOGISTICS

- USDA-ARS
  - Feedstock densification and logistics.
- Unknown
  - Identify refiners that need that type of organization.

Logistics

- Phillips 66
    - We want to become closer to growers, distributors, marketers, and public policy groups to better understand the supply chain for biomass to drop-in fuels.
- Unknown
    - POET's Project Liberty is demonstrating collection and stockpiling and logistics of corn stover.
- Ag Ventures Alliance
    - We could organize our farmers and have them sign long term supply contracts for corn stover at some determined price.
- Renmatix
    - Feedback to help with feedstock supply chain development

Conversion

- Iowa Energy Center
    - R & D, Pre-commercial conversion technology development, and demonstration
- Phillips 66
    - We are developing thermochemical technologies that produce drop-in fuels from biomass. These two technologies are currently in the pilot plant phase.

Workforce Development/Public & Policy Support

- Iowa State University
    - Strategy for thermochemical biofuels
- Iowa State University
    - Participate in "industry" organization

Public & Policy Support

- Iowa Economic Development Authority

- Working with private sector companies who are commercializing thermochemical-processing technologies.
- Future: develop financial incentives as new investment risk reduction tools specific to thermochemical technologies.

- Unknown
    - POET and many partners created Growth Energy, which is lobbying and public policy arm for industry renewable fuels.

PUBLIC & POLICY SUPPORT/OTHER

- Senator Tom Harkin (Alex Lynch)
    - Continuing to hold the line on RFS2 and ensure the success of the biofuels industry.
- BP
    - Could: lobby regulators for certainty regarding RFS2 regulations and goals.

OTHER

- Farm Bureau
    - May be able to assist with commercialization
- Howard Roe (Tall Corn)
    - POET is building a plant to handle corn stover in Emmetsburg; long-range plans are to build similar facilities at each plant (27).
- Unknown
    - Continue to work with Congress and the administration to create more stability in the industry.
- David Karson
    - Today: Student Guest
    - Future: Hopefully work on policy and financing in biofuel industry

Exhibit 10

WORKSHOP EVALUATION

CenUSA Bioenergy Roadmap to Commercialize Thermochemical Biofuels and Bio-products Processing in the Midwest Workshop

Dec. 11-12, 2012

1. What best describes your role?

- Researcher
- Biofuels producer
- Crop Grower Association Representative
- Government official
- Other

Researcher		Biofuels Producer		Crop Grower Association Rep.		Government Official		Other		Total	
14	41%	7	21%	2	6%	4	12%	7	21%	34	100%

2. What portion of this workshop did you attend?

- All or most
- About half
- Less than half

All or most		About half		Less than half		Total Response	
32	94%	1	3%	1	0%	34	100%

CenUSA Bioenergy is supported by Agriculture & Food Research Initiative Competitive Grant no. 2011-68005-30411 from the USDA National Institute of Food & Agriculture. For More information see www.cenusa.iastate.edu

3. **Rate your understanding of ideal feedstock characteristics for thermochemical processing BEFORE the workshop:**
   - 1 – Little or none
   - 2
   - 3
   - 4
   - 5 – In-depth, expert

1 - Little or none		2		3		4		5 – In-depth, expert		Total Response		Average Rating
3	9%	8	24%	8	24%	8	24%	7	21%	34	100%	3.24

4. **Rate your understanding of ideal feedstock characteristics for thermochemical processing AFTER attending the event:**
   - 1 – No better
   - 2
   - 3 – Better
   - 4
   - 5 – Much better

1 – No better		2		3 - Better		4		5 – Much better		Total Response		Average Rating
2	6%	3	9%	11	32%	13	38%	5	15%	34	100%	3.47

5. **Please rate the general technical content of the workshop.**
   - 1 – Too basic
   - 2
   - 3 – About right
   - 4
   - 5 – Too technical

1 – Too basic		2		3 – About right		4		5 – Too technical		Total Response		Average Rating
0	0%	2	6%	28	82%	4	12%	0	0%	34	100%	3.06

6. **Please rate your opinion about the length of the workshop (approximately 1 day).**
   - 1 – Too short
   - 2
   - 3 – About right
   - 4
   - 5 – Too long

1 – Too short		2		3 – About right		4		5 – Too long		Total Response		Average Rating
0	0%	2	6%	30	88%	2	6%	0	0%	34	100%	3.00

Gender
- Male
- Female

Male		Female		Total	
27	82%	6	18%	33	97%

7. Ethnicity (check all that apply)

- Black or African American
- American Indian or Alaska native
- Asian
- Native Hawaiian or other Pacific Islander
- White
- Hispanic or Latino

Black or African American		American Indian or Alaska native		Asian		Native Hawaiian or other Pacific Islander		White		Hispanic or Latino		Total	
0	0%	0	0%	0	0%	0	0%	31	94%	2	6%	33	97%

Comments

- Really long last day, maybe a break before dinner
- Suggest ISU andCenUSA get a couple more social scientists involved on people side for “quantitative sociology” (e.g. Carmen Bain)
- Helped greatly
- I would have liked the presentation from the producers (2:15 pm Tuesday session) to have been longer by one more hour so that they could have talked a bit more about their company
- Great workshop, Thanks!
- Good program on topic, maybe more on technoeconomic analysis of processes

Exhibit 11

Drivers & Barriers to Perennial Grass Production for Biofuels

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cenusa bioenergy

March 2013

The CenUSA vision is to create a regional system for producing biofuels from perennial grasses grown on land unsuitable or marginal for row crop production, while improving the sustainability of existing cropping systems through biomass crops that reduce runoff of agricultural nutrients and increase soil carbon sequestration.

At Iowa State University's 2012 Integrated Crop Management Conference, participants who attended a session on "Understanding the Economics of a System of Perennial Grasses for Bioenergy in the Central United States" learned about research in the expected costs and returns of perennial grass production, storage, harvest and transport. A follow-up survey measured their perceptions of establishing a switchgrass production system.

They were asked to rank both positive and negative aspects of or influences on a producer's decision to adopt switchgrass production. Results showed that respondents viewed the two **most important or most influential reasons to adopt** switchgrass production were:

- the opportunity to engage in an emerging market opportunity, and
- the conservation and habitat benefits of perennial grasses.

They identified the biggest barrier at this time is the lack of a current market for harvested grasses.

CenUSA researchers continue to discover and quantify the costs and returns to perennial grass production under different production and technology scenarios with varying amounts of inputs and on varying qualities of land. The information presented to session participants illustrated that perennial grass production can compete with returns to traditional row crop or hay production under specific conditions.

Generally, participants who responded to "*What marketing, contracting, or policy mechanisms would need to be available in order for you to consider switchgrass production on land you manage*?" indicated they would need:

- a Biomass Crop Assistance Program or something similar,
- government funding of an insurance or risk management product, or
- a minimum price guarantee with a contract.

Feedback from participants showed that producers and farm managers will decide whether or not to adopt a perennial grass crop based on the economics of the system. Perennial grass production must be shown to be economically feasible in their enterprises. At the same time, responses indicated a willingness to take into account the non-market benefits (i.e. environmental advantages and benefits from energy independence).

Risk will play a large role in the adoption decision. Even if perennial grass production can be shown to be economically feasible, producers want the guarantee of a market and price for their production.

Learn more at http://www.cenusa.iastate.edu.

This project is supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the National Institute of Food and Agriculture.

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Increasing Knowledge about Producing Biomass

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cenusa bioenergy

March 2013

Exhibit 12

CenUSA researchers are exploring the feasibility of thermochemical processes that convert biomass from perennial grasses to biofuels. By-products from these processes can be used as feedstocks, enhancing the value of the path from plant to biofuel.

A webinar titled "*Thermochemical Conversion of Biomass to Drop-In Biofuels*" on February 13, 2013 provided participants with an opportunity to learn about these processes and the feedstock options that result. Although response rate was low (12 out of 19), results suggest a knowledge gain for some participants in three areas:

- Characteristics of thermochemical feedstocks,
- Thermochemical processing pathways, and
- Thermochemical biofuel projects at the commercial scale.

Participants were queried on how many acres they influence, and how many people they expect to share this information with from the webinar.

The majority of respondents expect to reach 1 to 10 people with the information they acquired at the webinar. One person responded "more than 500 people," while two others expect to reach 101 to 500 people with the information they learned from the webinar.

An indicator used to measure impact asked respondents how many acres they influenced. Six participants reported they influence more than 1,000 acres, while 5 respondents said 0 acres, 1 said 1 to 50 acres, and 1 reported 500 to 1000 acres.

Participants represented various occupations, the most common of which was Extension (7 individuals out of 19), followed by academia and Federal or State Agency employees with 5 individuals representing each category.

Respondents varied in age. The majority of our respondents (8) were aged 30-49. Three were aged 18-29, four were 50-64, and four were 65 years or older. Five participants did not respond to this item.

Through this webinar CenUSA Outreach and Extension was able to reach 19 people to increase their awareness and knowledge about thermochemical feedstocks production and the processes that are needed at the commercial level, specifically those who responded to the survey. Those surveyed indicated they influence 6500 acres, of which some may be suitable for perennial grass production. We see a double multiplier effect: 1) that participants will reach more than 1000 people, and 2) they influence a significant number of potential acres for perennial grass production.

This project is supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the National Institute of Food and Agriculture.

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GENERAL INSTRUCTIONS FOR DATA COLLECTION

We will NOT take weekly measurements this year. Instead there are designated days for taking measurements and/or harvest.

- **Harvest Dates**
  Please take recordings within 3 days (either before or after) of the recommended harvest date. The harvest date was chosen based on the average days-to-maturity listed by the seed producers.

- **Measuring Heights and Widths of Plants:**
  Measure heights and widths of plants in each treatment and average the height and widths rounded to nearest ½ inch.

- **Measuring Counts and Weights of Crops:**
  Count all produce harvested by treatment such as beans, cucumbers, tomatoes, and asparagus, etc. Weigh all produce harvested from each treatment based on the **pounds and ounces** classification **mode** on the scale. It will have **TWO** decimal points example 0.0.00 **(WATCH FOR PROPER DECIMAL POINTS)** For example a tomato harvest could be 7 tomatoes in Treatment 1 with a total weight of 4.3.5 which equates to 4 lbs 3.5 ounces. Make sure it is then recorded as 4.3.5 (do not add any text – numbers and dots only)

- **Fruits/Vegetables Count**
  Each crop will have specific details on what size the produce should be when picked. Count the number of fruits and vegetables per treatment according to the specific details.

- **Measuring Blooms:**
  Blooms are measured as a rank. 1=1-25% open; 2=26-50% open; 3=51-75% open & 4= 76-100% open

- **Leaf Color:**
  A color key will be provided. This key is not comprehensive in scope of colors, so please just record it to the closest color it resembles. Record the general/average color of leaves on plants per treatment.

- **Leafy Crops Care and Harvest Information:**
  Remove outer leaves that may be in decline as needed for the sake of plant health prior to harvest dates. Harvest the leaf crops based on recommended dates and weigh total crops by treatment. Harvest all "leafy-type" crops by cutting off at ground level.

- **Thinning Plants**
  When thinning plants, do NOT pull the plants out. Instead, cut the weakest plants at ground level. Pulling plants may result in root damage on neighboring plants.

- **Eating and/or donating crops**
  All potatoes and carrots need to be collected for research purposes. If/when collecting produce for donations, only donate the crops from the Control treatments. Since this is still a research effort into collecting the necessary data on guidance of biochar use in specialty crops, the crops grown in biochar amended soils are not recommended currently for human consumption. Volunteers can make their own personal decisions about what to keep and eat.

INDIVIDUAL CROP GROWTH HABITS AND INSTRUCTIONS

Asparagus - Jersey Knight Hybrid

Harvest date to be determined by growth. Possible harvest date is the date the rest of garden is planted or…
…When to Pick: record measurements and harvest when at least 50% of spears are at mature height of 7-9"

The rest of the information below is for personal use only and care after the data collection day.

This predominantly all-male hybrid is widely adapted; It does well in all soils, including heavy clay types, and is highly resistant to rust, Fusarium and other diseases. Weed your asparagus patch regularly and apply a balanced fertilizer in fall. The foliage and canes (stems) will turn a golden color at the approach of cool weather and die after a heavy frost. Leave the canes standing until they break away easily from the crown. Then remove them and mulch the entire bed with an organic material for the winter. Spears 7-9"

- ✓ In the season of 2013 **cut a few spears from each plant over a period of two weeks when the plants reach a mature height of 7-8 inches.** Harvest by cutting spears at soil level with a sharp knife.
- ✓ In the season of 2014 **cut spears over a 3-4 week period**
- ✓ In the season of 2015 **cut spears over a 6-8 week period**

***NOTE**: You know it's time to stop harvesting when the tips of the spears become bumpy instead of smooth. The bumps are tiny buds. Take their appearance as a sign that the spears need to be allowed to grow into canes and foliage, which nourish the roots for next year's harvest. If well cared for, your plants will produce more and more shoots every year, forming clumps 18-24in. wide in 5 or 6 years.*

WHAT TO RECORD EARLY SEASON:

1. Date of Harvest
2. Record count of spears harvested at mature height (7-9") per treatment
3. Record total weight of spears harvested per treatment

WHAT TO RECORD LATE SEASON: within 3 days of August 24

1. Measure and record average plant height and widths per treatment

Basil - Italian Large Leaf - Harvest each treatment within 3 days of July 23

Large dark green leaves have mild sweet flavor. Slow-bolting, high-yielding. ***Height:*** *24-30";* ***Width:*** *N/A"*
Spacing: *18";* ***Transplants****-seed started indoors;* ***Maturity:*** *40-65 days*

WHAT TO PLANT:

1. Transplant 12 basil per row

WHAT TO RECORD:

1. Monitor for plant diseases/pests until harvest
2. On day of harvest, record count of basil plants in each treatment; measure and record average plant height and widths per treatment; record total weight per treatment

Watch for Basil Downy Mildew (http://blog.lib.umn.edu/efans/ygnews/2012/09/basil-downy-mildew-found-in-mi.html) and communicate findings to leaders and record when/if you see it.

Beans - Blue Lake 274 Bush – Starting within 3 days of July 14, harvest each treatment 2 times per week over a two week period for a total of 4 harvest times

*Grows bush, 15 to 18 inches tall, which bears a heavy crop of round pods, 6 to 7 inches long, very meaty and free of strings and fiber. **Height**: 15" to 18"; **Width:** 12" to 15"; **Direct Seed Spacing:** 2" to 12"; **Planting Depth:** 1"; **Maturity:** 52 days*

WHAT TO PLANT:

1. Direct sow row 60 seeds per plot according to package directions.
2. **NOTE:** Keep track of how many seeds were planted and how many germinated and record that data when other data is recorded
3. Once germinated, thin to 15 plants per row
4. Monitor for plant diseases/pests until harvest

WHAT TO RECORD:

1. Number of seeds that germinated
2. Number of total plants at harvest (any plant loss?)
3. Use leaf color key and record leaf color closest to the key (per treatment) **1st harvest only**
4. On day-of-harvest , measure and record average plant height and widths per treatment; count and weigh only the mature beans that are 6-7" long and count and weigh all beans over 7"in each treatment

Carrots – Seed Treat Hybrid - Harvest each treatment within 3 days of August 1

*Grows 6" long. Very sweet and crunchy. Japanese kuroda type has tapered spike shaped roots. Seed tapes: **Planting depth and thin as recommended on package.** **Maturity:** 70 days*

WHAT TO PLANT:

1. Plant 5'seed tapes (1/3 of 15' seed tape) per row, per treatment, based on label recommendations
2. After strong germination, thin to 20 plants per treatment - evenly spaced

WHAT TO RECORD:

2. Measure and record average plant height and widths per treatment
3. Use leaf color key and record leaf color closest to the key (per treatment)
4. Sort and record count of carrots between 5-7"; sort and record count of carrots less than 5"; sort and record count of carrots more than 7"; Record total count of carrots per treatment
5. Record total weight per treatment

Cucumber - Tasty Green Hybrid - Starting within 3 days of July 23, harvest each treatment 2 times per week over a two week period for a total of 4 harvest times

The crisp, juicy, tender fruits are slender, dark green, smooth skinned with small white spines. Best harvested when 9 to 10 inches long. Plants have good disease resistance.
***Direct sow:** seeds; **Planting Depth:** 1" **Spacing:** 12"; **Maturity:** 62 days*

WHAT TO PLANT:

1. Plant 3 seeds at each of the 3 outside bamboo stakes (total 9 seeds per treatment); Monitor for plant diseases/pests until harvest
2. Thin (cut-don't pull) to 1 (healthiest) plant per pole after plants get long enough to climb
3. Assist climber vines by tying them onto the poles

(CUCUMBERS CONTINUED…)

(CUCUMBERS CONTINUED…)

WHAT TO RECORD:

1. On harvest day, record number of plants per treatment that didn't survive (if any)
2. Use leaf color key and record leaf color closest to the key (per treatment) **1st harvest only**
3. Sort and record count of cucumbers between 8"- 11" and sort and record count of cucumbers more than 11" per treatment
4. Record total weight of cucumbers per treatment

Kale - Blue Curled Vates – SPECIAL NOTE: Harvest EVERY OTHER kale plant in each treatment within 3 days of August 1 - The remaining Kale should be left until hard frost.

Green leafy vegetable; Light frost improves flavor. Provides greens into late fall and winter. Can tolerate some shade. ***Height:*** *12-18";* ***Width:*** *9-12";* ***Spacing:*** *12";* ***Planting Depth****: 1/2";* ***Maturity:*** *60 days .*

WHAT TO PLANT:

1. Transplant 15 kale per row, per treatment (45 total)
2. Monitor for plant diseases/pests until harvest

WHAT TO RECORD:

1. Measure and record average plant height and widths per treatment
2. Use leaf color key and record leaf color closest to the key (per treatment)
3. Record number of any plants that died back
4. CAREFULLY harvest (7 plants) EVERY OTHER kale plant starting with the second plant in the row by cutting at ground level; a total of 7 plants should be cut and 8 plants should remain. (*NOTE: If there is dieback, it is more important to harvest only 7 plants to remain consistent with other sites, than to leave 8 plants behind)*
5. Record total weight of kale per each treatment; **It's important that all sites record readings from 7 plants per treatment**

Lettuce – Black Seeded Simson - Harvest each treatment within 3 days of July 7

Heirloom: Tender, buttery texture and pale green leaves. ***Maturity:*** *45 days* ***Direct sow****: seed tapes - Planting depth and thin to recommendations on seed packet.*

WHAT TO PLANT:

1. Plant 5'seed tapes (1/3 of 15' seed tape) per row, per treatment, based on label recommendations
2. After strong germination, thin to 10 plants per treatment - evenly spaced

WHAT TO RECORD:

1. Measure and record average plant height and widths per treatment
2. Use leaf color key and record leaf color closest to the key (per treatment)
3. Record number of any plants that died back
4. Record total weight per treatment

Pepper - King Arthur Hyb - Sweet Bell - **Harvest each treatment within 3 days of July 23 and a second harvest within 3 days of July 30**

*Grows well almost anywhere. Big, blocky 4 1/2 inch bells have thick, meaty walls. Flavor is sweet and crunchy whether harvested green or red. Sturdy 22 inch plants begin bearing early and keep on producing for exceptional yields. Tolerant to TMV and PVY. **Height**: 22"; **Width:** NA; **Spacing:** 18"-24"; **Maturity:** 61-62 days*

WHAT TO PLANT:

1. Transplant 8 pepper plants per row, per treatment (24 total)
2. Monitor for plant diseases/pests until harvest

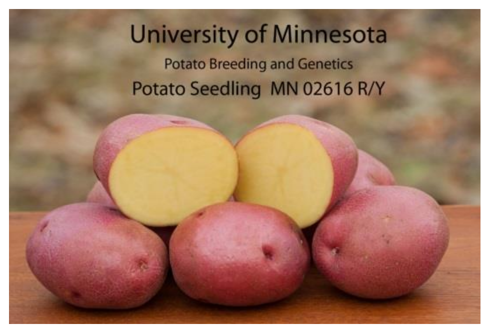
WHAT TO RECORD:

1. Measure and record average plant height and widths per treatment; **1st harvest only**
2. Use leaf color key and record leaf color closest to the key (per treatment); **1st harvest only**
3. Record number of any plants that died back
4. Pick only mature fruits of 4” or larger
5. Record count of mature peppers per treatment
6. Record weight of mature peppers per treatment

Runestone Gold Potato - - **Harvest each treatment within 3 days of August 24**

*A new UMN release. A mid to full-season variety. Dark green foliage. Tubers dark red skin, deep yellow flesh, round to oval uniform tuber. Harvest after tops turn yellow. **Spacing:** 18"; **Planting Depth:** 3-5" **Maturity:** 80-100 days*

WHAT TO PLANT:



1. Plant 3 healthy large eyes per treatment (9 total per site)
2. After plants are 8-1 inches tall, use a hoe and pile several inches of soil up around the stems. This is called hilling. This prevents exposure to the sun which causes tubers to become green and inedible.
3. Monitor for plant diseases/pests until harvest

WHAT TO RECORD:

1. Record weights of potatoes per treatment

Tomato - Celebrity Hybrid - **Harvest each treatment within 3 days of August 1 and a 2nd harvest within 3 days of August 8**

*(VFFNTASt) - Outstanding disease resistance and hybrid vigor make this tomato a standout. Strong determinate plants adapt well to bush, cage or short stake production. Fruit is large 8-10 oz. and deep red with exceptionally good flavor. Very productive with the ability to produce under a broad range of conditions. 1984 AAS Winner **Height**: 3-4"; **Width:** 3' **Fruit Size**: 8-10 oz; **Spacing:** 18"-24"; **Maturity:** 72 days*

WHAT TO PLANT:

1. Transplant 5 tomato plants per row, per treatment (15 total)
2. Remove lower leaves (bottom 1/3 of plant)and suckers as the plants matures.
3. Monitor for plant diseases/pests until harvest

WHAT TO RECORD:

1. Measure and record average plant height and widths per treatment; **1st harvest only**

(continued on next page)

(Tomatoes continued….)

2. Use leaf color key and record leaf color closest to the key (per treatment); **<u>1st harvest only</u>**
3. Record number of any plants that died back
4. Pick only mature fruits (note on comment section of reporting form if any fruits were over ripe
5. Record count of mature tomatoes per treatment
6. Record weight of mature tomatoes per treatment

ANNUAL FLOWERS - Take measurements and readings within 3 days of July 23

Annual flowers will all have similar needs for recording. Make sure to follow the "What to Plant" guide for each site/treatment.

WHAT TO RECORD:

1. Measure and record average plant height and widths per treatment
2. Use leaf color key and record leaf color closest to the key (per treatment)
3. Record number of any plants that died back
4. Measure and record average plant height and widths
5. Record blooms as a rank. 1=1-25% open; 2=26-50% open; 3=51-75% open & 4= 76-100% open

Deadhead spent blooms as needed and monitor for pests and diseases throughout season

Gazania Big Kiss White Flame

High impact color all summer. Carefree, sun-loving. Big Kiss gazanias thrive in tough conditions. Their super-sized, 4 1/2 inch, pinwheel striped blooms are nearly 50% larger than most other gazanias, topping bushy 8 to 10 inch mounded plants that fill out quickly in garden beds and containers. Start seed indoors. Allow 13 to 15 weeks from sowing to bloom.

WHAT TO PLANT:

1. Transplant 15 Gazania plants per row, per treatment (45 total)
2. Pinch back growing tips at time of transplanting to encourage bushing

Slavia Farinacea Victoria

The number one choice for cool blues. The classic, standard mid blue. Extremely prolific, dense spikes with neat, light gray-green foliage. Place all around your garden where they'll bloom all summer long. Start indoors 8 weeks before last spring frost. Shade tolerant.Sun: Full Sun, Part Sun; Height: 14-16 inches; Spread: 12-14 inches; Sowing Method: Indoor Sow ; Bloom Duration: 12 weeks.

WHAT TO PLANT:

1. Transplant 11 Salvia plants per row, per treatment (36 total)
2. Pinch back growing tips at time of transplanting to encourage bushing

Zinnia - Uproar Rose Hybrid

Bold, robust and absolutely eye catching. There's nothing shy about these neon rose double blooms that can measure up to 6 inches across. The vigorous plants are well-branched and loaded with blooms all summer. ***Height:*** *28" - 3';* ***Plant Width:*** *24"-27"* ***Bloom Width:*** *4-6";* ***Spacing:*** *12";* ***Transplants****-seeds started indoors* *(Continued on next page)*

(Zinnias continued…)

WHAT TO PLANT:

1. Transplant 12 Zinnia plants per row, per treatment (36 total)
2. Pinch back growing tips at time of transplanting to encourage bushing

PERENNIAL FLOWERS - Mums of Minnesota - Take measurements and readings per cultivar as noted

WHAT TO RECORD:

1. Measure and record average plant height and widths per treatment
2. Use leaf color key and record leaf color closest to the key (per treatment)
3. Record number of any plants that died back (if applicable)
4. Measure and record average plant height and widths
5. Record Blooms a rank. 1=1-25% open; 2=26-50% open; 3=51-75% open & 4= 76-100% open

Deadhead spent blooms as needed and monitor for pests and diseases throughout season

Mums of Minnesota – *'Betty Lou'*

Take measurements and readings within 3 days of August 23

WHAT TO MAINTAIN:

1. **DO NOT PINCH BACK**

*Early bloomer…red button with intermediate stem stiffness. **Height:** 10-12" 1st year & 2.5-3' 2nd year; **Plant Width:** 30" 1st year & 3' 2nd year; **Bloom Width:** 2.5" **Bloom Period:** August-frost*

Mums of Minnesota – *'Maroon Pride'*

Take measurements and readings within 3 days of September 14

WHAT TO MAINTAIN:

1. When spring height reaches 4-5", pinch the top 1/2" of each shoot. Continue pinching every 2 weeks until July 4.

*Dark red, slow fading, stocky, sturdy, stiff-stemmed fully double decorative flowers atop a medium height uniformly mounded plant. Plant has dark green foliage. **Height:** 15-18"; **Plant Width:** 28-30" w/18-20" stems; **Bloom Width:** 4-4.5"; **Bloom Period:** Early September-frost* *(Mums continued on next page…)*

Mums continued…)

Mums of Minnesota – *'Gold Country'*

Take measurements and readings within 3 days of September 28

WHAT TO MAINTAIN:

1. When spring height reaches 4-5", pinch the top 1/2" of each shoot. Continue pinching every 2 weeks until July 15.

Peachy-bronze, tinged-yellow mums; medium stiff stems. ***Height:*** *20 - 21";* ***Plant Width:*** *20 -21";* ***Bloom Width:*** *4.5";* ***Bloom period*** *Mid-September-frost*

UMN Northern Accents Shrub Roses – *'Lena'*, *'Ole'* and *'Sven'*

Take measurements and readings within 3 days of June 21

University polyanthas die back to the crown in winter, and by June will have grown to two feet tall, with a profusion of buds and blossoms. They bloom all season, and need no special winter care. No special pruning is required.

General Care: Deadwood should be removed in early spring; Deadhead spent blooms as needed and monitor for pests and diseases throughout season

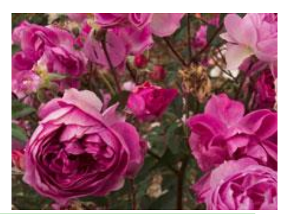
WHAT TO RECORD:

1. Measure and record average plant height and widths per treatment
2. Use leaf color key and record leaf color closest to the key (per treatment)
3. Record number of any plants that died back (if applicable)
4. Record bloom rankings 1=bud break; 3=half bloom; 5=flush

'Lena'

'Lena' is a spectacular single-flowered blush pink selection reminiscent of apple blossoms. ***Height:*** *2.5';* ***Plant Width:*** *2-3' rounded ;* ***Bloom Width:*** *1-2";* ***Flower Color:*** *blush pink single flowers;* ***Disease Resistant:*** *most resistant of three to black spot*

'Ole'



'Ole' is a semi-double blush pink rose fading to white. The dark blue-green foliage sets off the bright white/pastel pink blooms nicely. This rose produces flowers in very large clusters and produces the greatest number of individual blooms of the three. 'Ole' has a slightly more spreading growth habit of the three. ***Height:*** *2.5-3';* ***Plant Width:*** *3' spreading form;* ***Bloom Width:*** *1-2";* ***Flower Color:*** *blush pink fading to white*

'Sven'

'Sven' is compact, well-branched plant habit and abundant small flowers borne in large clusters. The exact shade of the flower color can vary throughout the growing season depending on growth conditions. Cooler temperatures in spring and fall lead to darker petal color and larger individual flowers. ***Height:*** *2.5-3' rounded form;* ***Plant Width:*** *NA;* ***Bloom Width:*** *1-2";* ***Flower Color:*** *Mauve/purple, double blooms-fragrant*

Possibilities for Aviation Biofuels in the Midwest

Chad Martin, PhD
Keith Johnson, PhD
Patrick Murphy, PhD
Purdue University

Exhibit 14

January 2013

An educational meeting for stakeholders in biofuels production was held to showcase research being done on biofuels and their prospect for adoption by the aviation industry. The prospect could include the use of fuels derived from bioenergy grasses that are being studied by the CENUSA project, a 7-state effort among Midwest land-grant universities who are exploring the use of perennial energy grasses for biofuels. The meeting was sponsored by the Indiana Biomass Energy Working Group (see sidebar).

Participants (N=55) were surveyed after the program to measure the value of the information presented. Respondents (n=48) indicated the following:

- Information presented was current as far as I know: 100% strongly agree/agree
- Visuals and handouts were easily understood and helpful: 96.2% strongly agree/agree
- The information provided me with new knowledge: 100% strongly agree/agree
- The new ideas presented will be helpful to me in my business: 96.2% strongly agree/agree
- The program provided me with new skills I would like to apply to my business: 91.3% strongly agree/agree
- The new skills will be useful in my business: 91.7% strongly agree/agree

The demographics of participants represented:

68% male
32% female

20% business owners/entrepreneurs
16% non-profit organizations
32% university faculty/staff
24% Extension professionals
8% government employees

86% between ages of 25 and 45
4% between ages of 18 to 25
10% over the age of 55

A new CenUSA exhibit (see photos below) was rolled out at the event that included:

• a table top display with samples of switchgrass, big bluestem, and indiangrass seeds and plant material with biochar,

• a question and answer interactive display about the history, research, and future of bioenergy crop production, and

• scrolling displays describing the CENUSA program.

The exhibit got a lot of attention. An opportunity to expand the reach of biofuels research being done by CenUSA came when a participant representing the commercial aviation alternative fuels industry suggested it be displayed at future aviation industry events.

This project is supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the National Institute of Food and Agriculture.

. . . and justice for all
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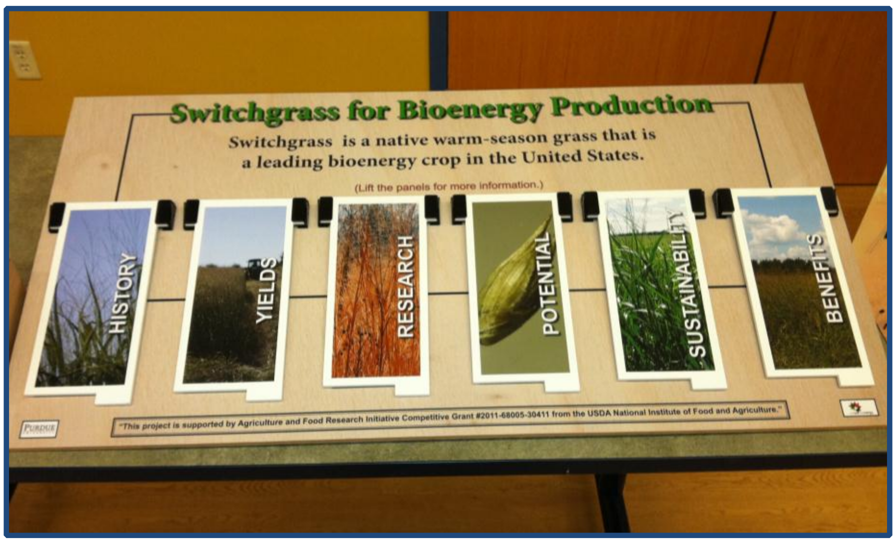
CENUSA Bioenergy Extension Exhibit

- Samples of bioenergy grasses including switchgrass, big bluestem, and indiangrass
- Box containing biochar and grass seed samples
- Interactive switchgrass information board
- Dual scrolling display units addressing the "Why, Where, and What" context of bioenergy grass production along with benefits



Indiana Biomass Energy Working Group:

This group is open to the public and is made up of diverse stakeholders in the bopenergy industry, government, trade organizations, universities, and entrepreneurs from throughout Indiana. Their goals are:

- to create a climate in the state of Indiana that fosters the growth of a viable renewable energy industry, protect our environment, and
- provide energy security and green jobs in our communities.

CenUSA Bioenergy Year 2 Publication & Presentation Summary

Objective 1. Feedstock Development

- **Presentations**

  - ✓ Dien, B. S., O'Bryan, P.J., Casler, M.D., Cott, M.A., Jung, H.G., Lamb, J.F.S., Mitchell, R.B., Sarath, G. & Vogel, K.P. (2013, April) *Variation in composition and yields among populations of alfalfa stems, reed canarygrass, and switchgrass for biochemical conversion to sugars and ethanol. ACS Abstract, April 7 – 11, 2013, New Orleans, LA.*

  - ✓ Sarath, G., Hammer, M., Saathoff, A., Mullen, C., Boateng, A., Mitchell, R.B., Vogel, K.P. & Sattler, S. (2013, April). Switchgrass*, cell walls and pyrolysis*. Presentation at the 35th Symposium on Biotechnology for Fuels and Chemicals, Portland, OR.

  - ✓ Sarath, Gautum, Hammer, N. Sasthoff, A., Mullen, C., Boateng, Akwasi, Mitchell, Robert B., Vogel, Kenneth P., & Sattler, S. (2013, April 29 - May 2). *Switchgrass, cell walls and pyrolysis. 35th Symposium on Biotechnology for Fuels and Chemicals.* (Abstract, oral presentation), Portland, OR.

  - ✓ Vogel, K.P. & Mitchell, R.B. (2012, August 30). *Training on the breeding, establishment, and* management *of perennial grasses for bioenerg*y. Crop Management and Diagnostic Clinic at the University of Nebraska. Forty-five farmers, certified crop consultants, professional agronomists, and farm management consultants attended the field clinic.

  - ✓ Stewart, Catherine L, Yuen, Gary Y., Vogel, Kenneth P., Pyle Jesse D. &. Scholthof, Karen-Beth G. (2013, August). *Panicum mosaic virus - a potential threat to biofuel switchgrass production.* Abstract accepted for the 2013 Annual Meeting of the American Phytopathological Society, Austin, TX.

- **Publications**
  - ✓ Dien, Bruce S., O'Bryan, Patricia J., Hector, Ronald E., Iten, Loren B. & Robert B. Mitchell, Qureshi, Nasib, Sarath, Gautum, Vogel, Kenneth P. & Michael A. Cotta. (2013). *Conversion of switchgrass to ethanol using dilute ammonium hydroxide pretreatment: influence of ecotype and harvest maturity. Environmental Technology* (Accepted).

  - ✓ Price, David L., and Michael D. Casler. (2013). *Predictive relationships between plant morphological traits and biomass yield in switchgrass*. Crop Sci. (in press).

  - ✓ Schaeffer, S., Baxendale, F., Heng-Moss, T., Sitz, R., Sarath, G., Mitchell, R. & Shearman, R. (2011). Characterization of the arthropod community associated with switchgrass (Poales: Poaceae) in Nebraska. *Journal of the Kansas Entomological Society*, *84*(2) 87-104.

Objective 2. Sustainable Feedstock Production Systems

- **Presentations**

  - ✓ Laird, D.A. (2012, August 4). *Sustainable integrated bioenergy-agronomic systems*. Presentation, Iowa State University BioCentury Research Farm, Annual Biofuels: Science & Sustainability Tour, Ames, IA.

  - ✓ Laird, D.A. (2012, August 25). *Biochar for master gardeners*. Presentation to CenUSA Master Gardener volunteers. Iowa State University, Ames, IA.

  - ✓ Mitchell, R.B. & Vogel, K.P. (2012, August 30). *Management of perennial grasses for bioenergy*. Field Day, University of Nebraska Crop Management and Diagnostic Clinic, University of Nebraska ARDC, Ithaca, NE. Note: Hosted a field day for 45 professional agronomists on the breeding, establishment.

  - ✓ Laird, D.A. (2012, September 12). *Contribution of soil biochar applications to sustainable bioenergy feedstock production.* Poster presented at the New Technology Expo to Reduce Nutrient Flux to Water Resources, Iowa State University, BioCentury Research Farm, Ames, IA.

  - ✓ Laird, D.A. (2012, September 17). *Potential of biochar to increase resiliency of agriculture*. Presentation, Iowa State University Bioeconomy Institute, Ames Iowa. Note: The presentation was for representatives from the Farm Bureau.

  - ✓ Laird, D.A. (2012, October 1). *The Biochar frontier*. Seminar, Purdue University, West Lafayette, Indiana, IN.

  - ✓ Moore, K.J. Birrell, S.J., Brown, R.C., M. Casler, M.D., Euken, J.E., Hayes, D.J. Hanna, M., Hill, J.D., Kling, C.L., Jacobs, K.L., Laird, D.A., Mitchell, R.B., Murphy, P.T., & Raman, R., Schwab, K.J. Shinners, K.J., Vogel, & Volenec, J.J. (2012, October 21). *Sustainable production and distribution of bioenergy for the Central USA: An agro-ecosystem approach to sustainable biofuels production via the pyrolysis-biochar platform (USDA-NIFA AFRI CAP, Project #2010-05073).* Paper presented at the ASA, CSSA & SSA International Annual Meetings, Cincinnati OH. Available at http://scisoc.confex.com/scisoc/2012am/webprogram/Paper74539.html

  - ✓ Laird, D.A., Rogovska, N., Fleming, P., Karlen, D. & Rathke, S. (2012, October 22). Biochar mitigation of allelopathy induced yield loss in continuous maize. Paper presented at the ASA, CSSA & SSA International Annual Meetings, Cincinnati OH. Available at http://scisoc.confex.com/scisoc/2012am/webprogram/Paper73119.html.
  - ✓ Parrish, D.K. Lee & T. Voigt. (2012, October 23). *Fertilizer and harvest timing effects on Miscanthus x giganthus and Panicum virgatum.* Poster presented at the ASA, CSSA & SSA International Annual Meetings, Cincinnati OH. Available at

http://scisoc.confex.com/scisoc/2012am/webprogram/Paper73205.html.

- ✓ Anderson, E., Voigt, T. & Lee, D.K. (2012, October 23). *Salt tolerance in Panicum virgatum and Spartina pectinata.* Poster presented at the ASA, CSSA & SSA International Annual Meetings, Cincinnati OH. Available at http://scisoc.confex.com/scisoc/2012am/webprogram/Paper73607.html.

- ✓ Mitchell, R.B., Vogel, K.P., Moore, K.J. & Schmer, M.R. (2012, October 23). *Location effect on switchgrass biomass loss and feedstock quality during storage*. Poster presented at the ASA, CSSA & SSA International Annual Meetings, Cincinnati OH. Available at http://scisoc.confex.com/scisoc/2012am/webprogram/Paper73186.html.

- ✓ Trybula, I. Chaubey, J. Frankenberger, S.M. Brouder, & Volenec, J.J. (2012, October 23). *Quantifying ecohydrologic impacts of perennial rhizomatous grasses on tile discharge, a plot level comparison of continuous corn, mixed prairie, upland switchgrass, and Miscanthus x giganthus*. Poster presented at the ASA, CSSA & SSA International Annual Meetings, Cincinnati OH. Available at http://scisoc.confex.com/scisoc/2012am/webprogram/Paper75175.html.

- ✓ Long, M., Volenec, J.J. & Brouder, S. M. (2012, October 24). *Nitrogen impacts on the yield and cell wall composition of contrasting sorghum lines used for biomass*. Paper presented at the ASA, CSSA & SSA International Annual Meetings, Cincinnati OH. Available at http://scisoc.confex.com/scisoc/2012am/webprogram/Paper75148.html.

- ✓ Burks, J., Brouder, S.M. & Volenec, J.J. (2012, October 23). *Seasonal accumulation and partitioning of carbon- and nitrogen-containing compounds in perennial bioenergy crops*. Poster presented at the ASA, CSSA & SSA International Annual Meetings, Cincinnati OH. Available at http://scisoc.confex.com/scisoc/2012am/webprogram/Paper72902.html.

- ✓ Dierking, R., Volenec, J.J. & Brouder, S.M. (2012, October 23). *The potential of maize and sorghum biomass* grown *on marginal sites*. Poster presented at the ASA, CSSA & SSA International Annual Meetings, Cincinnati OH. Available at http://scisoc.confex.com/scisoc/2012am/webprogram/Paper72548.html.

- **Publications**
  - ✓ Dowd, P.F., Sarath, G. Mitchell, R.B., Saathoff, A.J. & Vogel, K.P. (2012, August 10). Insect resistance of a full sib family of tetraploid switchgrass (Panicum virgatum L.) with varying lignin levels. *Genetic Resources and Crop Evolution*. DOI 10.1007/s10722-012-9893-8. Available at http://link.springer.com/article/10.1007/s10722-012-9893-8/fulltext.html.

  - ✓ Follett, R.F., K.P. Vogel, G. Varvel, Mitchell, R.B., & J. Kimble. (2012). Soil carbon sequestration by switchgrass and no-till maize grown for bioenergy. *Bioenergy Research*

2012, 5:866-875. DOI 10.1007/s12155-012-9198-y. Available at http://link.springer.com/article/10.1007%2Fs12155-012-9198-y - page-2

- ✓ Mitchell, R.B. & Schmer, M.R. (2012). Switchgrass harvest and storage. In A. Monti (Ed.) Switchgrass: A valuable biomass crop for energy: Green energy and technology (pp. 113-127).

- ✓ Woodson, P., S.M. Brouder & Volenec, J.J. (2013, May 6). Field-scale K and P fluxes in the bioenergy crop switchgrass: Theoretical energy yields and management implications. *J. Plant Nutrition and Soil Science* 2013, *000,* 1–13. DOI: 10.1002/jpln.201200294. Available at http://onlinelibrary.wiley.com/doi/10.1002/jpln.201200294/abstract.

Objective 3. Feedstock Logistics

- ***Fact Sheet: Optimizing Harvest Logistics Of Perennial Grasses Used For Biofuel*** *(2013).* CenUSA CoPd Kevin Shinners and CenUSA collaborator Pam Porter (Objective 9) produced the *Optimizing Harvest Logistics Of Perennial Grasses Used For Biofuel* factsheet which focuses on switchgrass and covers methods to optimize harvesting and processing switchgrass to reduce energy requirements, from cutting, drying, conditioning, baling, and bale handling. https://www.cenusa.iastate.edu/PublicFile/_GetPublicFile?publicFileId=64.

Objective 4. System Performance Metrics, Data Collection, Modeling, Analysis, and Tools

- **Presentations**

  - ✓ Hill, J. (2012, October). *Ethanol: Fact is stranger than fiction.* Lecture, ASABE Minnesota Section Fall 2012 Meeting, St. Paul, MN.

  - ✓ Hill, J. (2013, January). *Evaluating life cycle impacts of biomass production for bioproducts and bioenergy.* Catalysis Center for Energy Innovation, Minneapolis, MN.

  - ✓ Hill, J. (2013, January). *Biofuels: Life cycle impacts on land and air.* Workshop on the Nexus of Biofuels Energy, Climate Change, and Health, Institute of Medicine of the National Academies, Washington, DC.

  - ✓ Hill, J. (2013, February). *Green engineering – The future*. Presentation to the Society of Women Engineers Region H Conference, Minneapolis, MN.

  - ✓ Rabotyagov, S., Valcu, A. & Kling, C.L. (2012, December 12-13). Reversing the property rights: Practice-based approaches for controlling agricultural nonpoint-source water pollution when emissions aggregate nonlinearly. Presentation to the Global Environmental Challenges: The Role of China, Shanghai, China.

- **Publications**

  - ✓ Anderson-Teixeira, K. J., P. K. Snyder, T. E. Twine, S. V. Cuadra, M. H. Costa, E. H. DeLucia. (2012). Climate regulation services of natural and agricultural ecoregions of the Americas. *Nature Climate Change, 2*: 177-181. doi:10.1038/nclimate1346. Available at http://www.nature.com/nclimate/journal/v2/n3/full/nclimate1346.html.

  - ✓ Gonzalez-Ramirez, J., Valcu, A., Kling, C.L. 2012, August). An Overview of Carbon Offsets from Agriculture. *Annual Review of Resource Economics 4*: 145-160. Available at http://www.annualreviews.org/doi/abs/10.1146/annurev-resource-083110-120016.

  - ✓ Schilling, Keith E., Gassman, Philip W., Kling, Catherine L., Campbell, Todd, Jha, Manoj, K., Wolter, Calvin F. & Arnold, Jeffrey G. (2013, June 8). The Potential for Agricultural Land Use Change to Reduce Flood Risk in a Large Watershed. Hydrological Processes (2013). Available at http://onlinelibrary.wiley.com/doi/10.1002/hyp.9865/abstract online. DOI: 10.1002/hyp.9865

Objective 6. Markets and Distribution

- **Drivers & Barriers to Perennial Grass Production for Biofuels (Keri Jacobs)** https://www.cenusa.iastate.edu/PublicFile/_GetPublicFile?publicFileId=62

Objective 7.Health & Safety

- A presentation has been accepted for the Biomass and Biofuels session of the *2013 North American Agricultural Safety Summit* hosted by the Agricultural Safety & Health Council of America. The event will be in Minneapolis, Minnesota on September 25-27, 2013.

Objective 8. Education

- Guretzky, J., Kohmetscher, A. & Namuth-Covert, D. (2013) Grass seed structure and seedling emergence. *Nat. Sci. Educ. 42*:1-1. doi: 10.4195/nse.2012.0018w. Available at https://www.agronomy.org/publications/nse/abstracts/42/1/nse.2012.0018w?access=0&view=pdf.

Objective 9. Extension and Outreach

- CenUSA Collaborator John Hay (Extension and Outreach) served on the panel *The Future of Energy in Farm & Agricultural Production: A Panel Discussion of Natural Gas, Hydrogen, Ethanol, Biodiesel, Wind Power, Solar, and More* which was moderated by CenUSA

Collaborator Keith Glewen (Extension and Outreach) (December 4, 2012).

- CenUSA Collaborator Chad Martin (Extension and Outreach) presented information on CenUSA on perennial biomass to the Indiana Biomass Energy Working Group (January 8, 2013).

- CenUSA Collaborator Chad Martin (Extension and Outreach) presented information on CenUSA and perennial grasses and bioenergy to the Indiana Small Farms Conference (March 1 - 2, 2013).
- Bill Lazarus (CenUSA Extension Economics and Decision Tools team) has developed the *Watershed Nitrogen Reduction Planning Tool (NBMP.xlsm) for Comparing the Economics of Practices to Reduce Watershed Nitrogen Loads* (Spring 2013). The tool is currently being used to help states that drain into the Gulf evaluate if, where and how to use perennial grasses to mitigate nitrogen and phosphorus loads in the water (See: http://faculty.apec.umn.edu/wlazarus/documents/nbmp_overview.pdf).

- **Publications**

  Increasing Knowledge about Producing Biomass. (Amy Kohmetscher, March 2013) Evaluation report on the "Thermochemical Conversion of Biomass to Drop-In Biofuels Posted to web 7/24/13 Posted to Website

  ✓ Hagen, L. (2013). *2012 CenUSA Biochar Demonstration Gardens.* Available at https://www.cenusa.iastate.edu/PublicFile/_GetPublicFile?publicFileId=61.

  ✓ **Possibilities for Aviation Biofuels in the Midwest**. (Chad Martin, Keith Johnson & Patrick Murphy, 2013, April) https://www.cenusa.iastate.edu/PublicFile/_GetPublicFile?publicFileId=63

  ✓ Namuth-Covert, D., Guru, A., Fairchild, M., Kohmetscher, A., Leingang, D., Speth, C., Sherman, J., Lee, D., Mamo, M., Brakke, M., Guretzky, J. & Murphy, P. (2012, October 12). Learning object repository becomes of age – Reflecting on 13 years of faculty development and technology applications. Presentation to the 18th Annual Sloan International Conference on Online Learning: University of Nebraska-Lincoln, Montana State University, University of Minnesota and Purdue University.

  ✓ **Research Summary: Biofuel Quality Improved by Delaying Harvest of Perennial Grass** *Research shows decreased nitrogen contaminants in perennial grasses, such as switchgrass, grown for biofuel by delaying harvest.* http://www.extension.org/pages/67841/research-summary:-biofuel-quality-improved-by-delaying-harvest-of-perennial-grass

Informational Materials

CenUSA has produced the following videos and webinars in Project Year 2 (August 1, 2012 – July 31, 2013.

- **Informational Videos**

  - ✓ **2013 Switchgrass Planting Practices for Stand Establishment** (5:17)(March 7, 2013). Stand establishment is critical to make growing switchgrass for biofuels economical. CenUSA and USDA-ARS researcher Rob Mitchell will walk you through the keys to successful switchgrass establishment. This video was created with the help of Rob Mitchell, Amy Kohmetscher, and Deana Namuth-Covert; filmed and edited by Ryan Cole at 3 Pillars Media. http://www.youtube.com/watch?v=vwBQ3aYpfmM

  - ✓ **Optimizing Harvest of Perennial Grasses for Biofuel** (4:50) (January 2013). CenUSA CoPd and University of Wisconsin professor Kevin Shinners discusses new systems to harvest, handle, store and transport perennial grasses that will be used as biomass feedstocks (4:50) http://youtu.be/NMt5Ct-65-Y. Vimeo: http://vimeo.com/57621501.

  - ✓ **How to Measure Stand Establishment Using a Grid**. (9:05) (December 2012) http://youtu.be/AXZN7-PmldU. Vimeo: http://vimeo.com/cenusabioenergy/measure-stand-establishment

  - ✓ ***Harvesting a Native Grass for Biofuel Production*** (2:58) (September 2012). CenUSA Bioenergy CoProject Director and USDA scientist Rob Mitchell discusses the potential of a native grass, switchgrass, for use in biofuel production. http://www.youtube.com/watch?v=_RcJBURXwKc. Vimeo: http://vimeo.com/46249647

- **Webinars**

  - ✓ **An Overview of Switchgrass Diseases**. (48:37) (July 22, 2013) This webinar will give an overview of switchgrass diseases. Among the diseases that will be discussed are Panicum mosaic caused by a virus and rust and leaf spots caused by fungi. Because switchgrass is a native species requiring minimal management and because it has a high potential to sequester carbon, switchgrass has been identified as a potential biofuel species. As with any cultivated crop, diseases, insects, and weeds can be major constraints in switchgrass production. To date, not much research has been done on switchgrass diseases. Therefore, little is known about their etiology, epidemiology and impact on yield. http://youtu.be/xYKAYfKRHVs. Evaluation survey at unleducation.qualtrics.com/SE/?SID=SV_8fhgGZp7zKxpPPD
Vimeo: http://vimeo.com/cenusabioenergy/overviewofswitchgrassdiseases

  - ✓ **2013 - Thermochemical Conversion of Biomass to Drop In Biofuels** (515:37) (February 2013). CenUSA Bioenergy Co-Project Director and Iowa State University Distinguished

Professor Robert Brown discusses the merits of thermochemical processing of biomass for the production of fuels and bio-based products. http://youtu.be/Ua8She55qTc
Vimeo: http://vimeo.com/59676741.

Exhibit 16

cenusa bioenergy

Annual Progress Report

Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform

October 2012

Agriculture and Food Research Initiative Competitive Grant
No. 2011-68005-30411

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NOTICE

This quarterly report was prepared by Iowa State University and CenUSA Bioenergy research colleagues from Purdue University, United States Department of Agriculture-Agricultural Research Service, University of Illinois, University of Minnesota, University of Nebraska, Lincoln, University of Vermont, and the University of Wisconsin in the course of performing academic research supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the United States Department of Agriculture National Institute of Food and Agriculture ("USDA-NIFA).

The opinions expressed in this report do not necessarily reflect those of Iowa State University, the USDA-NIFA, Purdue University, United States Department of Agriculture-Agricultural Research Service, University of Minnesota, University of Nebraska, Lincoln, University of Vermont, or the University of Wisconsin and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it.

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Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (AFRI-CAP 2010-05073)

Quarterly Report: August 1, 2012 – October 30, 2012

PROJECT ADMINISTRATION

1. Project Organization and Governance Accomplishments

CenUSA Bioenergy ("CenUSA") Project Director Ken Moore continues to lead the overall research effort. Chief Operating Officer Anne Kinzel and Financial Manager Val Evans handle project administration and business affairs, including all aspects of CenUSA operations, including coordination, communication, and data sharing among institutions across the states. In addition, Kinzel is responsible for the day-to-day project management and the planning and preparation of reports, meetings, data management, and maintenance of the project's public face. Evans is responsible for all project financial activities, including the development and implementation of administrative policies and procedures to ensure effective financial operation and oversight of the project.

a. Project Progress

Each of the nine CenUSA objectives is showing satisfactory progress towards meeting the project's timelines and deliverables schedules.

b. Featured Activities

- **CenUSA Annual Meeting**

  The 2012 Annual Meeting was held August 7-9, 2012 in Lincoln, Nebraska (See Exhibit 1. 2012 Annual Meeting Agenda). Ken Vogel, Supervisory Research Geneticist at the USDA Agricultural Research Service-Northern Plains and leader of the CenUSA *Germplasm to Harvest* research group, hosted the meeting.

  Over 80 people attended the meeting, including nine of 12 Advisory Board members. In addition, eleven graduate students and post-docs were able to attend as well as six employees of the USDA-ARS.

  Each of the nine research objective research teams provided progress reports to update CenUSA colleagues and to respond to questions from colleagues, the CenUSA Advisory Board and from NIFA attendees Mark Poth and William Goldner As had been the case in the 20111 Annual Meeting, Advisory Board members participated actively in the meeting and provided valuable feedback to the participants.

One entire day was spent touring the Feedstock Development objective's regional evaluation sites near Mead, Nebraska. There was also time for each of the research objectives to meet and discuss Year 2 activities and to make further plans for Year 2 and beyond.

Participants completed a meeting evaluation that will be used in planning the 2013 annual meeting (See Exhibit 2. 2012 Annual Meeting Evaluation).

- **American Society of Agronomy, Crop Science Society of America and Soil Science Society of America International Annual Meeting, October 21-24 Cincinnati, Ohio**

  CenUSA Project Director Ken Moore, CenUSA Co-Project Directors Stuart Birrell, Robert C. Brown, Michael Casler, Dermot J. Hayes, Mark Hanna, Jason Hill, Cathy Kling, Keri Jacobs, David Laird, Robert Mitchell, Patrick Murphy, Raj Raman, Kevin Shinners, Kenneth Vogel[8] and Jeffrey Volenec and CenUSA COO Anne Kinzel attended the "Sustainable Production and Distribution of Bioenergy for the Central USA: An Agro-Ecosystem Approach to Sustainable Biofuels Production Via the Pyrolysis-Biochar Platform meeting held in conjunction with the ASA, CSSA and SSSA International Annual Meeting in Cincinnati, Ohio. Ken Moore provided an update on the CenUSA project.

- **Workshop: Roadmap to Commercialize Thermochemical Biofuels and Bio-Products Processing in the Midwest.**

  CenUSA CoProject Directors Robert C. Brown and Jill Euken have collaborated with Project Director Ken Moore and Project COO Anne Kinzel and the Iowa State University Bioeconomy Institute to create the workshop *Roadmap to Commercialize Thermochemical Biofuels and Bio-Processing in the Midwest*. The event will be held December 11-12, 2012 at the Iowa State University Scheman Center in Ames, Iowa. CenUSA, the ISU Bioeconomy Institute, the USDA Central-East Regional Biomass Research Center, Iowa NSF EPSCoR (grant number EPS-1101284 from NSF), and the Iowa Energy Center will sponsor the event.

  Program Focus – **Optimal Feedstocks and Commercial Pathways.** The workshop is intended to bring together and help foster relationships among researchers, industry, and agricultural producers in the Midwest as they work together to create a roadmap to commercialize thermochemical processing of biofuels and bio-products (See Exhibit 3. Proposed Agenda. Workshop: Roadmap to Commercialize Thermochemical Biofuels and Bio-Products Processing in the Midwest).

Specific goals include defining the optimal biomass feedstocks for thermochemical processing and identifying commercial pathways for the technologies in the Midwest. Representatives of leading companies working to commercialize thermochemical processing of biomass are attending the workshop. Each will describe their company's technologies, goals, desired type of feedstock, and amount of biomass needed for commercial operation.

A panel of experts on plant breeding and agronomy will describe how different agricultural approaches can be used to optimize the yield of biomass feedstocks while minimizing undesirable components such as ash, nitrogen, and moisture. Experts from Iowa State and the USDA will also discuss non-fuel products such as heating oil, biochar, and bioasphalt that can be made by thermochemically processing biomass. Representatives from the producers group will describe their organizations, past projects, and criteria for new projects.

✓ **Proposed Sessions**

Sustainability Challenges to Biofuels – Byron Johnson, P66

Thermochemical Conversion Technologies 101 – Robert Brown, CenUSA & ISU

Impacts of Facility Scale and Location on Thermochemical Biorefinery Costs – Mark Wright, ISU

Preparing the Midwest to Supply biomass Feedstocks for Thermochemical Processing – Ken Moore, CenUSA & ISU

Non-fuel Products from Thermochemical Processing: Heating Oil, Biochar as a Soil Amendment, and Bioasphalt – Prasad Gupte, DOE, David Laird, CenUSA & ISU, and Chris Williams, ISU)

✓ **Proposed Panels**

Ideal Feedstock Characteristics for Thermochemical Processing of Biomass

Optimizing Plant Breeding, Agronomy, and Logistics for Thermochemical Processing

Establishing Linkages Between Thermochemical Biorefiners and Midwest Biomass Feedstock Suppliers

✓ **Invited Industry Participants**

Archer Daniels Midland

BP

Chevron

Frontier Labs

Gas Technology Institute (GTI)

ICM

KiOR

P66

Renmatix

Honeywell UOP

Virent

Other attendees include researchers and representatives from producers of first-generation biofuels, agricultural crop growers associations (Ag Ventures Alliance, IDEA, Iowa Corn Growers, Iowa Farm Bureau, KAAPA, Lincolnway Energy, Stine Seeds, Tall Corn Ethanol, West Central Coop) and government officials, and experts from the CenUSA project (Birrell, R.C. Brown, S. Brown, Casler, Euken, Hayes, Mitchell, Moore, Raman, Schmer, Vogel, & Volenec), and members of the CenUSA Advisory Board (Bennett, Binder, Mellage, Schiltz and Weis).

- **CenUSA Planning & Collaboration Meeting – December 12-13, 2012**

  Immediately following the Roadmap Workshop the CenUSA executive team will meet in Ames to discuss commercialization and transdisciplinary opportunities for the CenUSA project. This meeting will provide Co-Project directors with the opportunity to engage in additional research planning and share information from fall 2012 harvest activities. (See Exhibit 4. Proposed Planning and Collaboration Meeting Agenda).

c. Advisory Board

The Advisory Board continues to provide valuable feedback and advice to the research team. The Advisory Board was a strong presence at the August 2012 annual meeting, as nine of the 12 members were able to attend the meeting. The Board members provided extensive feedback to each of the Objective teams. At the conclusion of the meeting Board members provided their observations and opinions regarding the project's accomplishments to date. (See Exhibit 5. Reactions to 2012 Annual Meeting – August 2012: CenUSA Bioenergy Project Advisory Board Grouped Comments)

New Board Member. By late summer 2012, board member Ben Steffen, an agricultural producer from Nebraska, was no longer able to participate on the board and recruitment was reopened. In September 2012, Bryan Mellage joined the Advisory Board. Mr. Mellage is a producer and agricultural implement dealer from Auburn, Nebraska with over 30 years experience in the agriculture and implement industries. Mr. Mellage has a very strong interest in biofuel and biomass energy farming.

2. Coordination, Collaboration, and Communication

- **Executive Team Meetings.** The Co-Project directors representing each of the nine objectives continue to meet monthly with Ken Moore, Anne Kinzel and Val Evans via online meetings held in CenUSA's dedicated Adobe Connect meeting room. The virtual meeting room allows for documents to be viewed by all participants, enhancing communications and dialogue between participants. Tom Binder, the Advisory Board chair also attends these meetings, to ensure there is an Advisory Board presence during these important project gatherings. Beginning in January 2013, the Education Objective has scheduled its *CenUSA Research Seminar Series* to coincide with the monthly Co-Project director meeting. The Research Seminars will be held in the CenUSA Adobe Connect meeting room from 3:10-4PM Central Time between January and July 2013.

  Each seminar will focus on the work of a CenUSA objective. The seminar format will begin with a 15-minute talk by a project Objective Co-project director and will be followed by a 15-minute talk by one of the graduate students involved in the work of the objective. The seminar will conclude with 20 minutes of question and answer time.

Table 1. 2013 Seminar Topic Schedule	
January 25	Objective 1 - **Feedstock Development**
February 22	Objective 2 - **Sustainable Feedstock Production Systems**
March 29	Objective 3- **Feedstock Logistics**
April 26	Objective 4 - **System Performance Metrics, Data Collection, Modeling, Analysis and Tools**
May 31	Objective 5 - **Feedstock Conversion and Refining: Thermo-chemical Conversion of Biomass to Bio-fuels**
June 28	Objective 6 - **Markets and Distribution**
July 26	Objective 7 - **Health & Safety**

- **Objective and Team Meetings.** All nine CenUSA Objectives participate in scheduled meetings using the CenUSA Adobe Connect meeting room or in face-to-face meetings.

- **2013 Annual Summit.** The advance planning for the 2013 annual summit is complete. The meeting will be held July 30 - August 2, 2013 in West Lafayette, Indiana. Jeff Volenec, Professor in the Department of Agronomy at Purdue University and Co-Project Director of CenUSA's Sustainable Feedstock Production Systems Objective, will host the 2013 CenUSA Summit.

- **Communication Platforms.** CenUSA continues to focus on expanding the quality and sophistication of the CenUSA website (www.cenusa.iastate.edu) and other social media opportunities.

  The website continues to expand content for both internal and external project stakeholders (industry professionals, agricultural and horticultural producers, educators, agency personnel, community leaders, extension educators, and the general public). The website continues to be used broadly to disseminate reports, learning modules, articles, and webinars. We also use the website to promote CenUSA events and activities such as educational meetings, webinars, media events, eXtension bioenergy learning modules, field days, and networking opportunities. We have been able to secure further assistance within the Iowa State University community to add additional features to the website which will be deployed in the second quarter (November 2012 – January 2013).

  We have used a Twitter account (@CenUSAbioenergy) to provide project updates, and disseminate information regarding the availability of CenUSA publications. We have been able to generate a strong core of followers within the biofuels community.

  Our project webinars and videos are disseminated in three separate sites: 1) via the CenUSA website, 2) via a "YouTube Channel" (www.youtube.com/user/CenusaBioenergy; and via a Vimeo site (https://vimeo.com/cenusabioenergy) to provide an additional outlet to view CenUSA webinars and videos. We now have a complement of 13 videos available on the two websites. (See Exhibit 6. CenUSA Video/Webinar List)

- **Financial Matters.** The Administrative Team continues to monitor all project budgets and subcontracts to ensure adherence to all sponsor budgeting rules and requirements.

- **Program Matters.** We will continue to focus on project coordination, communication, meetings and data sharing across Objectives, and on reaching the revised timelines milestones.

- **Upcoming Public Events (Administrative Presence).** CenUSA will share a booth with the Iowa State University Bioeconomy Institute at the 2013 I*owa Renewable Fuels Summit and Trade Show* which will be held in Des Moines, Iowa (January 30, 2013).

3. Publications, Presentation, Proposals Submitted

We prepared a new CenUSA brochure that focuses on thermochemical conversion (See Exhibit 7. The Biomass to Energy Challenge).

Germplasm to Harvest

Objective 1. Feedstock Development

Feedstock Development focuses on developing perennial grass cultivars and hybrids that can be used on marginal cropland in the Central United States for the production of biomass for energy. In 2012, the focus is on the establishment of new breeding and evaluation trials.

1. Planned Activities

- Initial stand counts will be made on switchgrass, big bluestem, and indiangrass yield tests planted in the spring of 2012.
- Switchgrass, big bluestem, and indiangrass selection nurseries and breeder seed increase nurseries transplanted to field nurseries in 2012 will be maintained. No Year 1 data will be collected.
- Biomass yield harvests will be made on a family basis for all selection nurseries established in 2011. Samples will be collected from all family plots for quality analyses. Heading and other data collection will be completed.
- Seed will be harvested from specific polycross nurseries and increase fields for use in additional testing.
- Insects will be monitored biweekly through the end of September.
- A series of greenhouse screening evaluations will be carried out to evaluate selected switchgrass, big bluestem, and indiangrass cultivars and experimental strains for their susceptibility to greenbugs and sugarcane aphids.
- Initiate work on identifying virus species causing severe symptoms on some plants in the field and begin conducting statistical analyses of disease severity data.
- Initiate testing of fungal and bacteria stains isolated from diseased leaves for pathogenicity on switchgrass.
- Initiate work on isolating fungi from diseased crown and root tissue of switchgrass.
- Initial biomass mineral composition data will be collected on a standard set of switchgrass samples representing specific biomass types and harvest maturities.
- Composition analyses: we will hire and train a technician to carry out analyses of additional expected project samples.

- Initial analyses on switchgrass biomass standards completed for composition and pyrolysis tests.
- In the pyrolysis research, TGA Instrument's *Specialty Library* will be used to perform kinetic analyses of the switchgrass samples and determine the average activation energy, pre-exponential factor and order of reaction for each sample based on TGA results. These variables will be correlated to full composition data when available.
- Continue analyses work, including the statistical analyses, of the relationship between pyrolysis products and composition of biomass from switchgrass genotypes known to differ genetically for biomass composition and for biomass of different cultivars harvested at different maturity stages.
- Big bluestem and indiangrass sample set developed for comprehensive analyses and initial NIRS scans of samples completed.

2. Actual Accomplishments

- **Stand evaluations of multi-location yield tests**. (M. Casler, K. Vogel, & Cooperators). Thirty-nine trials were planted in May 2012 and three resulted in failed stands, one for each of the three species. Of the 36 successfully established trials, 13 experienced some loss in the number of cultivars, due to seed dormancy problems (See Objective 1, Table 1). Of these 13 trials without the full complement of cultivars, three belonged to switchgrass, eight to big bluestem, and two to indiangrass. The full complement of cultivars successfully established at nine locations for switchgrass, four locations for big bluestem, and 10 locations for indiangrass. Big bluestem took the hardest hit during establishment, but eight of 13 trials resulted in successful establishment of 10 cultivars (all except Bonanza and Sunnyview). Six locations had significant annual grassy weed issues that will not allow for a final determination of stands until spring green-up in 2013. At that time, we will make a final determination of which trials will move forward for data collection. Overall, the establishment of these trials of three different species in which 46 different cultivars or experimental stains being tested can be considered to be a success since 44 cultivars or experimental strains were at a minimum of 10 locations each. This was a major accomplishment considering the drought conditions that existed in the region during most of the growing season.

  Because the seedlots used in the study came from different breeding programs and commercial seed companies and hence had germination and seed dormancy or hard seed tests conducted by different laboratories, all the seed lots were sent to the *Nebraska Crop Improvement Association* and the Nebraska Department of Agriculture's *Seed Testing Laboratory* (a joint laboratory) for germination tests without a pre-chill treatment and a pre-chill treatment to break dormancy. Some of the seed lots had significant amounts of seed dormancy. The results from the seed tests will be used with the stand information obtained in the spring of 2013 to quantify the effect of germination percentages and seed dormancy on stand establishment.

- **Establishment and maintenance of switchgrass, big bluestem, and indiangrass breeding nurseries**. (K. Vogel & M. Casler) All planned nurseries were successfully established and maintained. Again, this was a major accomplishment considering the drought conditions that existed in the region during most of the growing season. All selection nurseries will be ready for data collection in 2013.

- **Biomass yield harvests were made on a family basis for all selection nurseries established in 2011**. (K. Vogel & M. Casler) All harvests were completed as scheduled by breeding programs at Lincoln and Madison during the late summer and autumn of 2012. Samples were collected for biomass analyses. Heading date and height information was collected on specific nurseries being used in molecular marker research.

- **Seed will be harvested from specific polycross nurseries and increase fields for use in additional testing and increase**. (K. Vogel). Seed was harvested as scheduled from irrigated seed increase nurseries as planned and several non-irrigated switchgrass nurseries. Because of severe drought conditions, no seed was harvested from five non-irrigated indiangrass polycross nurseries and four non-irrigated big bluestem polycross nurseries. Seed had been harvested from these nurseries in previous years and was used in the yield trials and the breeding nurseries. The intent of the 2012 seed harvests was to replenish seed supplies of the experimental strains for potential use in seed increase for potential cultivar releases based on the yield test results. The lack of seed harvest in 2012 did not affect the research in progress. Plans are in progress to develop portable irrigation systems for use on the grass seed isolations if the current drought persists.

Insects will be monitored biweekly through the end of September. (Tiffany Heng-Moss and staff at UNL) Sampling was initiated to identify and monitor potential arthropod pest and natural enemies associated with switchgrass and other bioenergy grasses. Samples were collected every two weeks from May through September using pitfall traps and yellow sticky traps from switchgrass, big bluestem, and Indiangrass nurseries. Samples are being processed to identify potential pests and beneficial arthropods and characterize their seasonal abundance.

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Table 2. Summary of stands in multi-location yield tests.						
Location	Switchgrass establishment	Switchgrass cultivars	Big bluestem establishment	Big bluestem cultivars	Indiangrass establishment	Indiangrass cultivars
Ames, IA	Satisfactory	22	Moderate	12	Moderate	12
Arlington, WI	Excellent	22	Satisfactory	10	Satisfactory	12
Brookings, SD	Moderate	22	Moderate	12	Moderate	12
Chatham, MI	Satisfactory	22	Unsatisfactory	7	Moderate	9
Columbia, MO	Moderate	22	Moderate	12	Moderate	12
Grand Rapids, MN	Moderate	14	Moderate	8	Moderate	12
Marshfield, WI	Satisfactory	22	Satisfactory	10	Satisfactory	12
Mead, NE	Satisfactory	22	Moderate	10	Satisfactory	12
So. Charleston, OH	Unsatisfactory	0	Moderate	12	Moderate	12
Spooner, WI	Excellent	22	Satisfactory	10	Satisfactory	12
State College, PA	Satisfactory	20	Moderate	8	Unsatisfactory	5
Urbana, IL	Satisfactory	22	Satisfactory	10	Satisfactory	12
West Lafayette, IN	Moderate	16	Unsatisfactory	5	Moderate	9
Number of Cultivars Planted		22		12		12

- **A series of greenhouse insect screening evaluations will be conducted on switchgrass, big bluestem, and indiangrass cultivars**. (Tiffany Heng-Moss and staff at UNL) The greenhouse screening evaluations were initiated as planned and are underway to evaluate selected switchgrass, big bluestem, and Indiangrass cultivars and experimental strains for their susceptibility to greenbugs and sugarcane aphids.

- **Initiate work on identifying virus species causing severe symptoms on some plants in the field & begin conducting statistical analyses of disease severity data**. (G. Yuen, UNL) Methods for rating virus and leaf spot disease severity were developed and used to evaluate plants in several switchgrass spaced-planted breeding nurseries. Virus ratings were collected on every plant in four switchgrass breeding nurseries and a large genetic study. Leaf spot ratings were made on two switchgrass breeding nurseries. All data has been entered into databases and is ready for statistical analyses.

- **Initiate testing of fungal and bacteria stains isolated from diseased leaves for pathogenicity on switchgrass**. (Gary Yuen, UNL). Research is in progress. There were major disease problems on four big bluestem selection nurseries (Objective 1, Figure 1).

This is the most severe disease problem that Ken Vogel has seen on big bluestem. It is believed that drought stress imposed on the plants enabled the plant pathogens to overcome the plant's resistance to the pathogens. Plants in the nursery were scored for disease severity and half-sib families were harvested for biomass yield to document the combined effect of drought and diseases on biomass yields in comparison to the two previous years. This unexpected disease problem illustrates the need for plant disease work on perennial grasses grown for bioenergy. Potential sources of resistance were identified.

- **Initiate work on isolating fungi from diseased crown and root tissue of switchgrass**. Research is in progress.

Figure 1. Effect of drought and diseases on big bluestem biomass yields

ARS Bamboo C2 big bluestem, UNL ARDC, September 10, 2010.

ARS Bamboo C2 big bluestem, UNL ARDC, September 27, 2012.

- **Initial biomass mineral composition data will be collected on a standard set of switchgrass samples representing specific biomass types and harvest maturities**. Five switchgrass standard samples have been developed that will be used to develop baseline data on mineral element composition of biomass. The five samples represent both lowland and upland switchgrass harvested at different maturity stages. The bulk samples have been subdivided into multiple replicate sub-samples. The replicated sub-samples are ready to be sent to commercial analytical laboratories that use different technologies for determining mineral concentration. The information will be used to determine the variation that exists within and among laboratories for mineral composition determinations and to determine the extent of variation among methods across laboratories. This baseline information is needed to identify the best methods to be used by the researchers on this project and the biofuels industry for measuring mineral concentration of perennial grass biomass and identify potential laboratory problem areas.

- **Composition analyses - Hire technician to carry out analyses of additional expected project samples; develop laboratory capabilities to conduct analyses**. (Bruce Dien, ARS-Peoria). The appropriate analytical equipment required to carry out cell wall analysis and other chemical analyses was obtained and configured for the analyses and a technician has been hired to perform the analyses.

- **Initial analyses on switchgrass biomass standards completed for composition and pyrolysis tests**. We found significant differences in condensable gas composition between pyrolyzed samples. Non-catalytic pyrolysis produced statistically significant differences in yields of acids, KAA, aromatics, nitrogens, and phenols, while catalytic pyrolysis produced significant differences only in yield of sugars. Analysis using an outside model developed by Aaron Saathoff (ARS Lincoln) found differences between samples in Guaiacol, Syringol, and some lignin-derived compounds. Additional research is in progress.

- **Pyrolysis research. TGA Instrument's *Specialty Library* will be used to perform kinetic analyses of switchgrass samples**. (A. Boateng) Kinetic analysis was performed on TGA results from switchgrass samples. From this analysis, the only switchgrass biomass property that correlated with significant differences in kinetic properties was harvesting time. Additional research is in progress.

- **Continue analyses on the relationship between pyrolysis products and composition of biomass from switchgrass genotypes known to differ genetically for biomass composition**. Laboratory analyses are complete. Final statistical comparisons are in progress. Initial results indicate switchgrass genotypes (from populations developed by generations of divergent breeding for biomass digestibility) that were significantly different in biomass composition, differed in pyrolysis product yields. These findings are the result of cooperative work between A. Boateng and ARS-Lincoln staff.

- **Big bluestem and indiangrass sample set developed for comprehensive analyses and initial NIRS scans of samples completed**. Several thousand-plant samples have been reviewed for both species and samples are in the process of being selected for additional NIRS work prior to samples being sent to B. Dien and A. Boateng for composition and pyrolysis analyses. This work is slightly behind schedule because a laboratory technician had to be replaced. The position will be open for recruitment in the near future and when filled, it is expected the work will be back on schedule within a few months.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule with the exception noted above regarding the hiring of a new laboratory technician.

4. Plans for Next Quarter

- Biomass samples collected during the summer and autumn 2012 will be dried, ground, and scanned for their NIRS spectral profiles. Selected samples will be selected for laboratory analyses by ARS-Lincoln, comprehensive compositional analyses by B. Dien (ARS-Peoria) and pyrolysis by A. Boateng (ARS-Wyndmoor) will be initiated.

- Clonal pieces of switchgrass plants will be moved from the field to the greenhouse for intermating during the winter months (K. Vogel, Lincoln).

- Seed harvested during the autumn of 2012 will be cleaned and tested. Seed of one experimental stain will be made available for seed producers pending official cultivar release (K. Vogel, Lincoln, M. Casler, Madison).

- Plant Canada milkvetch seedlings in the greenhouse for four breeding populations for potential use in different Midwest Plant Adaptation Regions. Plant seedling for Partridge Pea selection nurseries. (K. Vogel, Lincoln).

- Insect sampling plans will be developed for the summer of 2013. (T. Heng-Moss, Vogel, Mitchell, & Casler). Continue identification of insects collected in 2012.

- Complete statistical analyses of 2012 virus ratings of switchgrass genotypes (Yuen, Vogel).

- Continue to screen selected switchgrass, big bluestem, and Indiangrass cultivars and experimental strains for their susceptibility to greenbugs and sugarcane aphids (T. Heng-Moss, UNL).

- Compositional analyses. Complete training of technician in plant cell wall compositional analysis and initiate full laboratory composition analyses capacity (B. Dien, ARS-Peoria).

- Continue py-GC/MS and TGA experiments and associated statistical analysis on 2012 sample sets of switchgrass. Prepare for initial analyses of big bluestem, and indiangrass samples.

- Initial draft of manuscript on effect of genetic differences in biomass composition of 12 divergent switchgrass genotypes on pyrolysis products completed for review.

5. Publications, Presentations, and Proposals Submitted

- B S. Dien, P.J. O'Bryan, Michael D. Casler, Mi. A. Cott, H.G. Jung, J.F.S. Lamb, R.B. Mitchell, G. Sarath, and K.Vogel. "Variation in Composition and Yields Among Populations of Alfalfa Stems, Reed Canarygrass, and Switchgrass for Biochemical

Conversion to Sugars and Ethanol," ACS Abstract, New Orleans, Louisiana, April 7 - 11, 2013.

- Robert B. Mitchell, Kenneth P. Vogel, and Marty R. Schmer. "2012 Switchgrass (Panicum virgatum) for biofuel production." http://www.extension.org/pages/26635/switchgrass-panicum-virgatum-for-biofuel-production, July 24, 2012.

- Vogel, Kenneth P., and Robert. B. Mitchell. "Training on the breeding, establishment, and management of perennial grasses for bioenergy." Presentation, University of Nebraska Crop Management and Diagnostic Clinic. (August 30, 2012). Note: Forty-five farmers, certified crop consultants, professional agronomists, and farm management consultants attended the field clinic. See Extension and Outreach report for impact.

Objective 2. Sustainable Feedstock Production Systems

The Sustainable Feedstock Production Systems objective focuses on conducting comparative analyses of the productivity potential and the environmental impacts of the most promising perennial grass bioenergy crops and management systems using a network of 14 fields strategically located across the Central United States. The overarching goal is to produce a quantitative assessment of the net energy balance of candidate systems and to optimize perennial feedstock production and ecosystem services on marginally productive cropland while maintaining food production on prime land.

1. Planned Activities

- Monitor growth of newly established perennial system and factor plots. At some locations photo-document establishment and growth on a near-weekly basis.

- Continue to monitor the weed pressure and use control measures as necessary.

- Harvest plots for biomass (where it makes sense to do so) at/near the killing frost for each location, and subsample biomass for compositional analysis.

- Continue soils analysis; some soil samples will be analyzed for nitrate levels to a depth of 60 cm.

- Design and test greenhouse gas GHG monitoring system for new system plots.

- At some locations, continue to maintain and collect the light interception and height measurements for the comparison trial.

2. Actual Accomplishments

- **Iowa State University**

  ✓ **Armstrong Farm**. The corn crop was harvested and population assessments were done on perennial treatments; switchgrass establishment was very poor due to abnormal drought. Annual surface soil samples were collected from each plot. Laboratory work is in progress to analyze soil cores for aggregate stability, bulk density, and moisture retention. Particle size distribution of bulk soil samples has been completed.

  ✓ **Agronomy and Ag Engineering Farm**. Additional biochar at the rate of 5.4 tons per acre was applied to existing plots. Total rate of biochar on those plots is now 13.6 tons per acre.

- **USDA-ARS, Madison**.

  Biomass yield, soil samples, and biomass-quality samples were collected at two locations in Wisconsin in 2012 (Arlington and Marshfield, HZ4 and HZ3, respectively). Harvest stages and dates were: anthesis (mid-August) and killing frost (mid-October). The third and fourth harvest treatments (early winter and post-winter) will be made in late November 2012 and early April 2013.

- **University of Minnesota - Factor analysis plots, Becker, MN**.

  ✓ Monitored growth and weed pressure of newly established plots throughout the growing season. Growth was slow due to loamy sand soil with low organic matter. We ceased irrigation in late July and less than 1.5" of rain was received in August and September. Did not apply herbicide.

  ✓ Conducted stand frequency analysis. Some plots may need reseeding in 2013, particularly the low-diversity mix, which had the lowest stand frequency of the protocol grasses.

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- ✓ Harvested factor analysis plots on October 30, 2012 using Carter harvester and biomass was weighed wet in the field (Figure 3). Two subsamples (0.25m x 0.25m) were collected from each subplot, stored in plastic bags under cool conditions and weighed in the laboratory. We conducted a visual estimate of grass/weed content for each subsample. Subsamples are drying and will be processed for dry matter and nutrient analysis.

Figure 2. Bioenergy Switchgrass, Sept. 11, 2012

Figure 3. "Shawnee" at Harvest, Oct. 30, 2012

- **University of Illinois**

  - ✓ **Factor Analysis Plots**. The factor analysis plots at the University of Illinois bioenergy research farm at Urbana had poor establishment due to severe drought from May through August and weed pressure during late summer. However, many seedlings were observed and a decision to replant will be based on stand counts in spring 2013. Feedstocks included were low diversity mix (big bluestem, indiangrass, and sideoats grama), 'Shawnee' and bioenergy switchgrass, prairie cordgrass, and a mixture of prairie cordgrass with big bluestem and Miscanthus.

  - ✓ **Comparison Field Trial**. Feedstocks included in the comparison field trial at the University of Illinois were four different prairie cordgrass accessions, *Miscanthus x giganthus*, a big bluestem local ecotype, and 'Kanlow' switchgrass. Light interception and height data were measured on a weekly basis on these plots from March through November of 2012. The plots were harvested on November 15, 2012. Biomass yield and chemical compositions will be compared among the tested populations in response to the wet marginal land situation where they were grown.

- **Purdue University**

  Factor Analysis Plots and Research. Findings/observations include:

✓ **Southern Purdue Agricultural Center**. The Southern Purdue Agricultural Center (SEPAC) is located near Butlerville, Indiana. The SEPAC plots were harvested October 29, 2012. Perennials at this site include the biomass switchgrass, a mixture comprised of equal amounts of big bluestem and indiangrass, and *Miscanthus x g.* all seeded in 2011. Yield data is not yet available, but observations indicate that all three perennial systems survived the drought/heat of 2012, but have relatively low yields. Biomass sorghums at this site and grew much better than maize (control) at every N rate. Although data is not yet available, maize yields were negligible (e.g., 6 plants/4 row plot) while all sorghums established and grew surprising well considering the limited rainfall and high summer temperatures (see Figure 5 below).

Figure 4. 2012 Big Bluestem Harvest

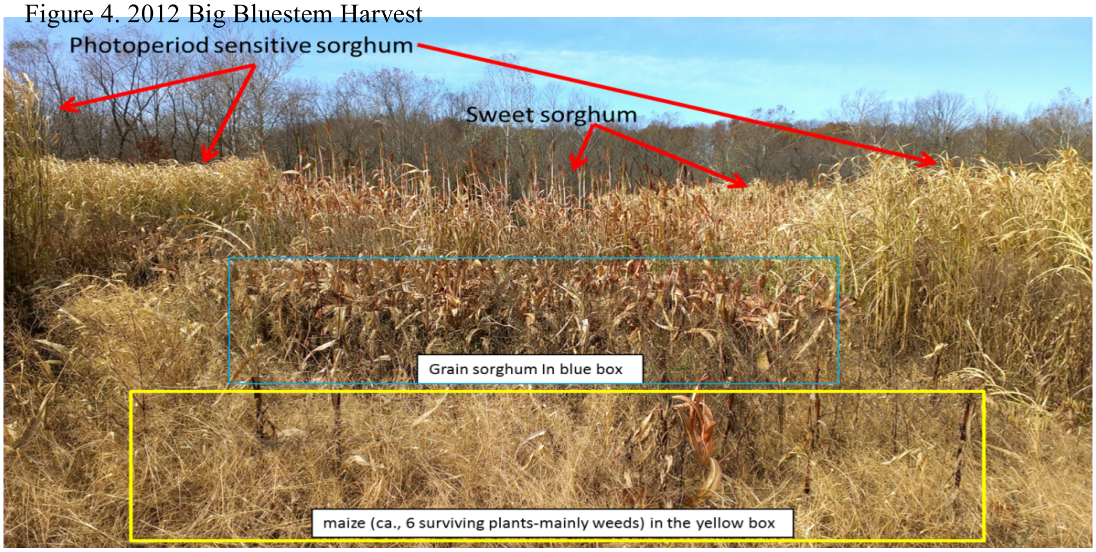

Figure 5. Southern Purdue Agriculture Center Plantings

- ✓ **Northeast Purdue Agricultural Center (NEPAC)**. Plots at this location performed slightly better than at SEPAC because of one or two timely rain events that mitigated some, but not all of the drought effects. Large visual differences in agronomic performance between maize (poor) and the biomass sorghums were apparent. The perennial biomass systems (seeded in 2011) survived the drought but yields will be low because of lack of moisture. These plots are scheduled for harvest during the week of November 5 to 9, 2012.

- ✓ **Throckmorton Purdue Agricultural Center (TPAC)**. Like SEPAC and NEPAC, large differences in dry matter yield were observed among the biomass sorghums and maize. About half of the maize plants in each plot died during the drought, and those that survived had much reduced growth. The annual biomass systems were harvested the week of October 15-19, 2012 and data are currently being analyzed. The perennial **biomass** systems established in 2011 also survived at this location; however, we anticipate low biomass yields because of drought and heat stress. This location also has N, P, and K fertility as management factors applied to pre-established stands of both switchgrass (two studies) and *Miscanthus x g*. Fertilizer effects on biomass yield are not visually apparent. This is not surprising since extreme drought and high temperature stress generally overrides any positive effects of fertility. Analysis of fiber, P, K, and N from the 2011 harvest of these fertility factor-analysis plots was completed. We will harvest all perennial plots at this location on November 1, 2012 and data analysis will commence shortly thereafter.

System Analysis Plots. Findings include:

- ✓ Drought also reduced growth of plants in the systems analysis plots, with large reductions in maize growth visually apparent (see Figures 6, 7 and 8, below).

  Maize grain and stover yields (control system) are anticipated to be reduced by approximately 50 percent. Sorghum appears to have tolerated the heat/drought better than maize, and it resumed growth in mid-August (see center photo above). The unfertilized native prairie system survived well, but yield will be reduced by drought. Both the switchgrass and *Miscanthus x g* tolerated the drought and we anticipate reasonable biomass yields from these systems despite the drought and heat stress. Greenhouse gas measurements on these plots continued throughout the growing season. Weeds and insects were controlled as needed using best management practices. These plots were harvested for biomass the week of October 29-November 2, 2012.

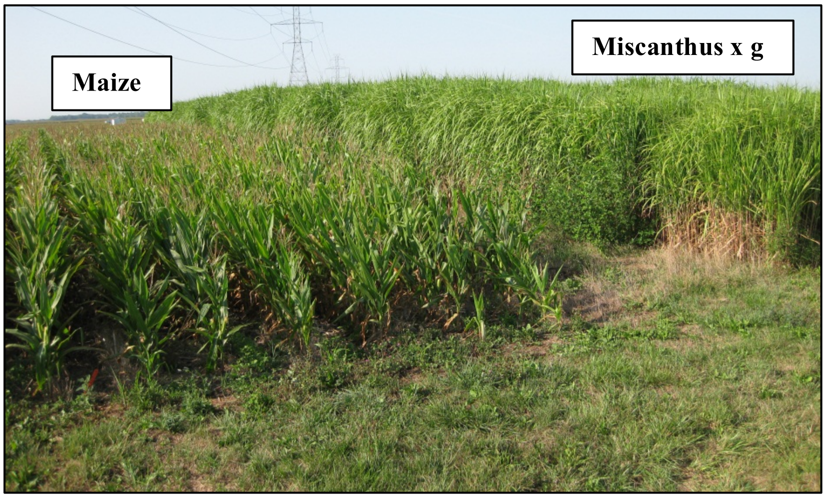

Figure 6. Maize and Miscanthus x g

Figure 7. Maize, Sorghum, Prairie

Figure 8. Miscanthus x g and Switchgrass

- **USDA-ARS, Lincoln**

✓ **Factor Analysis Plots**. The Factor Analysis plots at the University of Nebraska Agricultural Research and Development Center (ARDC) near Mead, NE will not be harvested in 2012 due to drought. Feedstocks at this site include 'Shawnee' and bioenergy switchgrass, bioenergy big bluestem, a low diversity mixture comprised of big bluestem, indiangrass, and sideoats grama, and a bioenergy mixture all seeded in 2012. All stands are well established and exceed minimum stand frequency requirements. Additional stand frequency data will be collected in spring 2013.

✓ **Systems Analysis Plots**. Drought reduced plant growth and yield in the systems analysis plots. However, maize grain yield averaged 102 bushels/acre for the three control system replicates, even though April through August precipitation was more than 9 in. below the long-term average. A target of 50 percent of the stover was removed from each replicate and averaged 1.44 tons/acre. A winter triticale cover crop was planted on half of each replicate on September 18, 2012 and acceptable stands have established (see photos below).

Figure 9. Maize Stover Removal

Figure 10. Triticale Cover Crop

✓ In the perennial feedstock fields, stands are excellent and averaged 84 percent for bioenergy switchgrass, 68 percent for big bluestem, and 60 percent for the low diversity mixture (see photos below). Weeds were managed as needed using best management practices. Insects were sampled in these plots through September 2012. These fields were not harvested for biomass due to drought, but two 3 ft. x 25 ft. strips will be harvested from each feedstock replicate at 30-d intervals throughout the dormant season (weather permitting) to determine harvestable dry matter loss over time. Yield estimates for the baseline harvest in October were 3.4 tons/acre for bioenergy switchgrass, 1.2 tons/acre for big bluestem, and 1.9 tons/acre for the low diversity mixture. These harvest strips will be georeferenced using GPS located and the effects of harvest during drought will be evaluated.

Figure 11. Switchgrass

Figure 12. Big Bluestem

Figure 13. Low Diversity Mix

3. Explanation of Variance

Drought caused poor stand establishment for perennial feedstocks at some locations. We will develop a contingency plan for replanting where needed.

4. Plans for Next Quarter

- Continue sampling biomass plots where feasible.
- Process harvested biomass samples for compositional analysis.

- Acquire soil samples following the completion of biomass harvests and analyze annual soil fertility samples for pH, electrical conductivity, and major nutrients.
- Assess stand frequencies in plots and fields in response to the drought.
- Begin summarizing and analyzing biomass yield data.
- Begin laboratory analysis of biomass samples.
- Ongoing baseline soil profile analysis will continue with measurements of bulk density, water retention, and aggregate stability via dry sieving.

5. Publications, Presentations, and Proposals Submitted

- Anderson, E., T. Voigt, & D.K. Lee. "Salt tolerance in *Panicum virgatum* and *Spartina pectinata*." Abstract 198-4. Inter. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Cincinnati Ohio, October 21-24, 2012. http://scisoc.confex.com/scisoc/2012am/webprogram/Paper73607.html.
- Burks, J., S.M. Brouder, & J.J. Volenec. "Seasonal accumulation and partitioning of carbon- and nitrogen-containing compounds in perennial bioenergy crops." Abstract 99-4. Inter. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Cincinnati Ohio, October 21-24, 2012. http://scisoc.confex.com/scisoc/2012am/webprogram/Paper72902.html.
- Dierking, R., J.J. Volenec, & S.M. Brouder. 2012. "The potential of maize and sorghum biomass grown on marginal sites." Abstract 247-5. Inter. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Cincinnati Ohio, October 21-24, 2012. http://scisoc.confex.com/scisoc/2012am/webprogram/Paper72548.html.
- Dowd, P.F., G. Sarath, Mitchell, R.B., A.J. Saathoff, & K.P. Vogel. 2012. "Insect resistance of a full sib family of tetraploid switchgrass (*Panicum virgatum L.)* with varying lignin levels." Genetic Resources and Crop Evolution. (Online DOI 10.1007/s10722-012-9893-8).
- Follett, R.F., K.P. Vogel, G. Varvel, Mitchell, R.B., & J. Kimble. 2012. Soil carbon sequestration by maize and switchgrass grown as bioenergy crops. Bioenergy Research. DOI 10.1007/s12155-012-9198-y.
- Laird, David. "Sustainable Integrated Bioenergy-Agronomic Systems." Presentation, 4th Annual Biofuels: Science & Sustainability Tour, Iowa State University, BioCentury Research Farm, August 14, 2012.

- David Laird. "Biochar: Presentation for Master Gardeners." Iowa State University, Ames Iowa, August 25, 2012.
- David Laird. Contribution of Soil Biochar Applications to Sustainable Bioenergy Feedstock Production. Poster, New Technology Expo to Reduce Nutrient Flux to Water Resources, Iowa State University, BioCentury Research Farm, September 12, 2012.
- David Laird. "Potential of Biochar to Increase Resiliency of Agriculture." Presentation, Iowa State University Bioeconomy Institute, Ames Iowa, September 17, 2012. Note: The presentation was for representatives from the Farm Bureau.
- David Laird. "The Biochar Frontier." Seminar, Purdue University, West Lafayette Indiana, October 1, 2012.
- David Laird, Natalia Rogovska, Pierce Fleming, Douglas Karlen & Samuel Rathke. 2012. Biochar Mitigation of Allelopathy Induced Yield Loss in Continuous Maize. Abstract 74-Inter. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Cincinnati, Ohio, October 21-24, 2012.
- M. Long, M., J.J. Volenec, & S. M. Brouder. Nitrogen impacts on the yield and cell wall composition of contrasting sorghum lines used for biomass. Abstract 383-8. Inter. Meeting of the Amer. Soc. Agron. Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Cincinnati, Ohio, October 21-24, 2012.
- Rob Mitchell, and Kenneth P. Vogel. "Field Day, Management of Perennial Grasses for Bioenergy." University of Nebraska Crop Management and Diagnostic Clinic, University of Nebraska ARDC, Ithaca, Nebraska, August 30, 2012. Note: Hosted a field day for 45 professional agronomists on the breeding, establishment,
- Mitchell, R., Vogel, K.P., Uden, D.R. 2012. "The feasibility of switchgrass for biofuel production." *Biofuels Journal*. 3:47-59.
- Rob Mitchell & Marty Schmer. "Switchgrass harvest and storage," in *Switchgrass: A valuable biomass crop for energy (Green Energy and Technology)*, ed. A. Monti. 113-127: London Springer-Verlag, 2012.
- Rob Mitchell, R., K.P. Vogel, K.J. Moore, & M.R. Schmer. 2012. Location effect on switchgrass biomass loss and feedstock quality during storage. Abstract 198-3. Inter. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Cincinnati, Ohio, October 21-24, 2012.
- Ken Moore, S.J. Birrell, R.C. Brown, M. Casler, J.E. Euken, D.J. Hayes, M. Hanna, J.D. Hill, C.L. Kling, K.L. Jacobs, D.A. Laird, R. Mitchell, P.T. Murphy, R. Raman, C.V.

Schwab, K.J. Shinners, K.P. Vogel, & J.J. Volenec. 2012. Sustainable production and distribution of bioenergy for the Central USA: An agro-ecosystem approach to sustainable biofuels production via the pyrolysis-biochar platform (USDA-NIFA AFRI CAP, Project #2010-05073). Abstract 26-3. Inter. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Cincinnati, Ohio, October 21-24, 2012. http://scisoc.confex.com/scisoc/2012am/webprogram/Paper74539.html

- A. Parrish, D.K. Lee & T. Voigt. 2012. Fertilizer and harvest timing effects on *Miscanthus x giganthus* and *Panicum virgatum*. Abstract 247-10. Inter. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Cincinnati Ohio, October 21-24 2012. http://scisoc.confex.com/scisoc/2012am/webprogram/Paper73205.html
- S. Thapa, A. Parrish, J. Guo, T. Voigt, & D.K. Lee. Evaluation of prairie cordgrass (*Spartina pectinata L.*) for abiotic stress tolerance and sustainable biomass production in marginal land. The 3rd Pan America Congress. Champaign, Illinois, July 16-18, 2012.
- E. Trybula, I. Chaubey, J. Frankenberger, S.M. Brouder, & J.J. Volenec. Quantifying ecohydrologic impacts of perennial rhizomatous grasses on tile discharge, a plot level comparison of continuous corn, mixed prairie, upland switchgrass, and *Miscanthus x giganthus*. Abstract 297-9. Inter. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer. Cincinnati, Ohio, October 21-24, 2012. http://scisoc.confex.com/scisoc/2012am/webprogram/Paper75175.html
- P. Woodson, S.M. Brouder & J.J. Volenec. 2013. Field-scale K and P fluxes in the bioenergy crop switchgrass: Theoretical energy yields and management implications. J. Plant Nutr. Soil Sci. (in press).

Objective 3. Feedstock Logistics

The Feedstock Logistics objective focuses on developing systems and strategies to enable sustainable and economic harvests transportation and storage of feedstocks that meet agribusiness needs. The team also investigates novel harvest and transport systems and evaluates harvest and supply chain costs as well as technologies for efficient deconstruction and drying of feedstocks.

1. Planned Activities

University of Wisconsin-Madison

Research activities planned during the late summer and early fall of 2012 included:

- Time and motion study of bale handling logistics;
- Field drying studies;
- Initiation of a bale storage study; and
- Quantification of the energy required to size-reduce perennial grasses by various means.
- Outreach activities included beginning production of a video and accompanying fact sheets concerning best harvesting practices.

Iowa State University

Research activities planned during the late summer and early fall of 2012 included:

- Determination of potential perennial biomass supply based on NASS data on cropland use and percent of marginal soils, and subsequent supply radius required.
- Integration of potential biomass perennial supply into a field harvest and logistics cost model, including the effect of producer demographics on harvest, storage and transportation costs.
- Analysis of harvest supply chain costs for multi-source cellulosic feedstock, including perennial grasses.

2. Actual Accomplishments

University of Wisconsin-Madison

- We harvested several fields using a round baler where bales were either randomly distributed or strategically accumulated in one field location as if the baler were equipped with a bale accumulator. Three CRP fields planted to either switchgrass or native grasses were used. Bales were loaded onto trailers by an experienced operator using front-end loaders and bale handling logistics quantified by time, distance traversed, and fuel use per bale. Overall, accumulation and strategic bale placement reduced time to load bales by 38 percent and total travel distance in the field by 40 percent. Although strategic bale handling did reduce total fuel required to handle bales, the specific fuel required to handle bales was small compared to that required for baling and transport.

  We investigated two techniques to further enhance the drying rate of switchgrass: intensive conditioning and wide-swath drying. Intensive conditioning involved mechanisms to hard crush the stem accompanied by shear forces to disrupt the waxy epidermis of the stem. Wide-swath drying involved a post-cutting tedding operation that distributed the crop across the full cut-width. Although not consistent across all studies, intensive conditioning generally was more effective than wide-swath drying at improving switchgrass drying rate. The combination of intensive conditioning and wide-swath drying consistently resulted in the greatest drying rate compared to the control treatment. This combination produced switchgrass moisture contents well below 15 percent (w.b.) in three separate studies.

We have begun to quantify the energy required to size-reduce perennial grasses either at the time of harvest or post-storage. Three size-reduction mechanisms were used: round baler with pre-cutter; forage harvester; and tub grinder. Using a pre-cutter on a baler increased bale density by 0 to 10 percent and increased specific fuel consumption by 10 percent to 23 percent with an average of 17 percent. A wide particle-size distribution resulted from use of the baler pre-cutter. Size-reduction by chopping with a forage harvester or by tub-grinding produced similar particle-size and mass throughputs. However, baling followed by post-storage tub grinding required more than twice the specific energy compared to chopping with a forage harvester.

Bales formed during the studies above were used in a storage study that will be conducted over the next six months. Four treatments were considered in this dry bale study, including indoor and outdoor storage and bales wrapped in plastic film (either individually or in a tube).

Finally, working with cooperators in CenUSA's *Outreach and Extension* objective (Objective 9), we took professional video of harvesting operations to begin production of an educational video on best harvesting practices. Fact Sheets will be developed to support the video.

Iowa State University

- NASS data on cropland use and percent of marginal soils have been integrated into a field harvest and logistics cost model. The model has been utilized on different case studies to determine the effect on changing the marginal row crop land in perennial grasses, and the subsequent effect this has on the supply radius for bio-refineries of different sizes. In general, the case studies show that the supply radius with the addition of perennial grasses replacing row crops on marginal land (dual feedstock supply), is similar to the supply radius for a single feedstock supply (row crop residues) with relatively high removal rates, and much less than the supply radius for a row crop residues with more conservative and sustainable removal rates.

  A Monte Carlo simulation for analysis and optimization of field harvest and logistics costs based on producer demographics has been developed. As expected the optimum machinery set varies by producer size and feedstock harvest and logistics costs are decreased with increasing producer size. This Monte Carlo optimization is in the process of being integrated into the field harvest and logistics cost model. The Monte Carlo simulation provides the ability for stochastic cost analysis and sensitivity analysis.

Analysis of harvest supply chain costs for multi-source cellulosic feedstock, including perennial grasses, and the subsequent effect the supply radius costs for bio-refineries of different sizes, is continuing, but has not been completed.

3. **Explanation of Variance**

University of Wisconsin-Madison

No variance has been experienced –we accomplished all that we had planned during this project period.

Iowa State University

No significant variance has been experienced –we accomplished all that we had planned during this project period. The only issue that has slightly delayed work has been the recruitment of graduate students. Additional personnel started in the middle of the first quarter (August – October 2012).

4. **Plans for Next Quarter**

University of Wisconsin-Madison

Now that our fall harvest period is complete we plan to:

- Analyze the collected data from the fall 2012 harvest;
- Manage our bale storage study;
- Begin design and fabrication on machines to combine cutting/intensive conditioning/tedding into a single operation; and
- Continue to collect post-storage size-reduction energy requirements of bales, but now using bales removed from storage during the winter months.

Iowa State University

Now that our fall harvest period is complete we plan to:

- Continue the development and integration of the Monte Carlo simulation into the field harvest and logistics cost model;
- Continue the development of laboratory scale equipment to study unit operations in the harvest, storage and transportation of perennial grasses; and

- Collaborate with CenUSA CoPds in Nebraska (Objective 2 - Sustainable Feedstock Production Systems) to collect machine performance and logistics data for large-scale harvest and transportation of perennial grasses.

5. **Publications, Presentations, and Proposals Submitted**

   None to report this period.

Objective 4. System Performance Metrics, Data Collection, Modeling, Analysis and Tools

This objective focuses on providing detailed analyses of feedstock production options and an accompanying set of spatial models to enhance the ability of policymakers, farmers, and the bioenergy industry to make informed decisions about which bioenergy feedstocks to grow, where to produce them, what environmental impacts they will have, and how biomass production systems are likely to respond to and contribute to climate change or other environmental shifts.

1. **Planned Activities**

   Iowa State University

   - Our first two broad tasks are to adapt existing biophysical models to best represent field trials and other data and to adapt existing economic land-use models to best represent cropping system production costs and returns.

   University of Minnesota

   - Planned activities for this quarter included continued work on Task 1 (Adapt existing biophysical models to best represent data generated from field trials and other data sources) and Task 2 (Adapt existing economic land-use models to best represent cropping system production costs and returns), and the initiation of Task 3 (Integrate physical and economic models to create spatially-explicit simulation models representing a wide variety of biomass production options).

2. **Actual Accomplishments**

   Iowa State University

   - We have acquired and are testing the most recent version of the Environmental Policy Impact Climate (EPIC) model. The model is a field-scale environmental model that can be used for estimating soil erosion losses, nitrogen and phosphorus movement, and soil carbon sequestration. An improved version of EPIC0810 is adopted here to account for emission estimates of two important greenhouse gases: nitrous oxide gas and N_2

(dinitrogen gas). This version of EPIC operates with daily climatic inputs, but the denitrification computations are performed on an hourly time step using inputs from the soil organic submodel. This version of EPIC also contains the improved soil carbon cycling functions developed by Izaurralde et al. (2006).

We completed the draft of a policy brief that provides an assessment of the potential for cellulosic feedstocks to reduce the frequency and magnitude of flood events in the Raccoon River Watershed in Iowa. We use a watershed based hydrologic model to represent changes in water movement under different land uses in the watershed. First, we develop a baseline scenario of flood risk based on the current land use and typical weather patterns. We then simulate the effects of varying levels of increased perennials on the landscape under the same weather patterns and compare the change in stream flows and water quality to the baseline scenario. A manuscript based on this paper is now completed and under review at a journal.

A major component of the ISU-Center for Agricultural and Rural Development modeling work in this objective involves the improvement of SWAT models for the Upper Mississippi River Basin and the Ohio Tennessee River Basin with USGS 12-digit subwatersheds. This effort is also supported by a National Science Foundation grant. During the first year of the project, significant progress in developing the model and populating it with data has been achieved. There is now a much denser subwatershed delineation; e.g., 5,279 12-digit subwatersheds versus 131 8-digit subwatersheds for the UMRB. This modeling structure will provide the ability to perform enhanced scenarios including greatly refined targeting scenarios to study placement of switchgrass and other biofuel crops in the landscape to evaluate the water quality and carbon effects at the landscape level. Initial calibrations of the model are complete.

University of Minnesota

- Our major accomplishment this quarter was finishing our comparison of U.S. federal agency bioenergy feedstock production scenarios for achieving Renewable Fuel Standard (RFS2) biofuel volumes. Major discrepancies among agency projections of future biomass availability were identified, as were underlying reasons for them. This work has been submitted to a journal for publication.

  Other ongoing projects include continued work on yield trial data to understand yield gaps in production, compiling production cost and return data for switchgrass, exploring different biodiversity models for use in our InVEST modeling, and writing of scripts to automate the modeling of biomass production placement on the landscape.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**

Iowa State University

Continue work on the first two tasks:

- To adapt existing biophysical models to best represent field trials and other data, and
- To adapt existing economic land-use models to best represent cropping system production costs and returns.

University of Minnesota

- Next quarter will include continued work on Tasks 1, 2, and 3, as well as continued work ahead of schedule on Task 4 (Evaluate the life cycle environmental consequences of various bioenergy landscapes).

5. **Publications, Presentations, and Proposals Submitted**

- Hill, Jason. "Ethanol: Fact is Stranger than Fiction." Lecture, ASABE Minnesota Section Fall 2012 Meeting, St. Paul, MN, October 2012.
- Rabotyagov, Sergey, Adriana Valcu, & Catherine L. Kling. "Reversing the Property Rights: Practice-Based Approaches for Controlling Agricultural Nonpoint-Source Water Pollution When Emissions Aggregate Nonlinearly." Presentation, Global Environmental Challenges: The Role of China Shanghai, China, December 12-13, 2012.
- Kling, Catherine L. National Science Foundation, "Climate and Human Dynamics as Amplifiers of Natural Change: A Framework for Vulnerability Assessment and Mitigation Planning, (Principal Investigator), 2012-2016, $480,000.
- Kling, Catherine L. "Markets and Regulation: Alternative or Complements." Presentation, 2012 Agricultural Outlook Forum, USDA, Washington DC, February 2012. http://www.card.iastate.edu/environment/presentations.aspx.
- Kling, Catherine L. "The Potential for Agricultural Land Use Changes in the Raccoon River Basin to Reduce Flood Risk: A Policy Brief for the Iowa Flood Center." Center for Agricultural Research and Development, Iowa State University, Ames, Iowa http://www.card.iastate.edu/environment/presentations.aspx
- Gonzalez-Ramirez, J., Adriana Valcu & Catherine L. Kling. "An Overview of Carbon Offsets from Agriculture." *Annual Review of Resource Economics* 4 (2012): 145-160.

Post-Harvest

Objective 5. Feedstock Conversion and Refining: Thermochemical Conversion of Biomass to Biofuels

The Feedstock Conversion and Refining Objective will perform a detailed economic analysis of the performance of a refinery based on pyrolytic processing of biomass into liquid fuels and will provide biochar to other CenUSA researchers. The team concentrates on two primary goals:

- Estimating energy efficiency, GHG emissions, capital costs, and operating costs of the proposed biomass-to-biofuels conversion system using technoeconomic analysis; and
- Preparing and characterizing Biochar for agronomic evaluations.

Sub-objective 1. Perform Technoeconomic Analysis

1. **Planned Activities**

   Identify project graduate student and develop plan for process modeling.

2. **Actual Accomplishments**

   A PhD student in Mechanical Engineering has been identified. This student has a year of experience developing and modifying process models in Chemstations Chemcad® and AspenPlus®. A background literature review has begun.

3. **Explanation of Variance**

   No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**

   Conduct preliminary literature search to develop plan for process modeling assumptions. We will determine the most appropriate modeling program and begin model development.

5. **Publications, Presentations, and Proposals Submitted**

   None to report this period.

Sub-objective 2. Prepare and characterize biochar

Identify project graduate student and develop plan for process modeling.

1. **Planned Activities**

   Evaluate water sorption isotherms on diverse biochars.

2. **Actual Accomplishments**

   Water vapor adsorption and desorption isotherms were determined for 14 biochars prepared from corn stover and alfalfa meal at temperatures ranging from 300 to 600 °C. The data set includes equilibrium water contents at six different relative humilities ranging between 11 to 98 percent RH.

3. **Explanation of Variance**

   No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**

   Laboratory work to analyze the anion exchange capacity of biochars that have aging in aqueous solutions under oxidizing conditions.

5. **Publications, Presentations, and Proposals Submitted**

   Michael Lawrinenko & David Laird. 2012. "Anion exchange capacity of biochar." Abstract 80-20 Inter. Meeting of the Amer. Soc. Agron.-Crop Sci. Soc. of Amer.-Soil Sci. Soc. of Amer.. Cincinnati, Ohio, October 21-24 2012.

Objective 6. Markets and Distribution

The Markets and Distribution objective recognizes that a comprehensive strategy that addresses the impacts to and requirements of markets and distribution systems will be critical to the successful implementation and commercialization of a regional biofuels system derived from perennial grasses grown on land unsuitable or marginal for the production of row crops. To create this comprehensive strategy the team focuses on two unifying approaches:

- The study and evaluation of farm level adoption decisions, exploring the effectiveness of policy, market and contract mechanisms that facilitate broad scale voluntary adoption by farmers; and

- Estimate threshold returns that make feasible biomass production for biofuels.

1. **Planned Activities**

Our team anticipated a total of five activities for the first quarter of the second year of the project:

- Continue to pursue access to farm-level recent CRP data;
- Work with other CenUSA objectives to develop a usable definition for marginal land;
- Analyze switchgrass trial data;
- Synthesize and distribute findings from our research intern's work; and
- Develop the survey instrument to be administered during ISU's Integrated Crop Management (ICM) Conference.

2. Actual Accomplishments

Each of our planned activities for Q1 Y2 has been addressed in some manner. Brief explanations for each are provided here.

- **Pursuit of Access to Farm-level Recent CRP Data**. Our team proposed to the USDA that a memorandum of understanding (MOU) be established to permit access to micro-level CRP data for signups 27 through 40 (recent general and continuous signups). These data include parcel-specific information on a type of marginal land that may be used in the project's system. Parcel specific information will be used to develop expectations of switchgrass biomass cost estimates, yields, and expected production penalty of switchgrass relative to competing crops. Our team anticipates a delay of several months before these data will be available to us, if the USDA is able to make them available. There has been no advancement of this activity during this quarter due to anticipated delays in data access allowance.
- **Marginal land definition**. We continue to explore placement scenarios for switchgrass on the landscape in collaboration with researchers and scientists in the CenUSA *System Performance Metrics* objective (Objective 4). These scenarios consider land quality attributes that fall within definitions of marginal land. Most recently, we have considered the attribute ranges of CRP lands.
- **Switchgrass Trial Data**. CenUSA Collaborator Richard Perrin is collecting switchgrass trial data from states relevant to our study. We expect this will continue into the next quarter.
- **Undergraduate Intern**. CenUSA Objective 6 CO-Project Directors Dermot Hayes and Keri Jacobs hosted an undergraduate research intern during the summer. The intern did research to understand the energy requirements of corn stover and switchgrass. The

research was presented at a summer undergraduate research symposium at ISU and also at CenUSA's annual meeting in Lincoln, NE, August 7-9, 2012.

Development of ISU's ICM Conference Survey Instrument. To better identify the barriers and drivers of implementation of the biomass production system, our team has arranged to participate in Iowa State University's Integrated Crop Management (ICM) extension series to be held November 28—29, 2012. We will engage in a collaborative effort with fellow CenUSA researchers Jill Euken, Chad Hart, Sorrel Brown, and Rob Mitchell to allow our team to gather information from producers and stakeholders that will be used to inform our modeling efforts and the policy and market mechanisms necessary to make the system viable. The session will provide landowners and farm managers with information about the expected costs, returns, and production details of planting switchgrass on the landscape. A survey will be administered to gain feedback from session participants that will assist us in fully responding to our objective **of s**tudying and quantifying the production and location-specific barriers and drivers of implementation of the entire system from producers of feedstock, producer groups and their stakeholders, and from biofuel producers.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Collaborative Efforts.

Our team engaged in numerous collaborative efforts –within CenUSA and with industry partners, during the quarter.

Collaboration and interaction among the CenUSA program areas includes:

- Jacobs worked with CenUSA colleagues Jason Hill, Cathy Kling, and other collaborators in the *Markets and Distribution* objective (Objective 4) to model placement of switchgrass on the landscape. Hill's and Kling's objective have expertise in such modeling, and Jacobs possesses information related to CRP that is useful in their efforts. Jacobs recently traveled to the University of Minnesota for a meeting with Jason Hill and his team to develop a plan going forward. The meeting was useful for Jacobs to understand the capability of Hill's team's modeling efforts and to understand their data needs so that Jacobs may help with those needs.

- In preparing for the 2012 ISU ICM Conference and the CenUSA Bioenergy Symposium to be delivered at the conference, Jacobs collaborated with researchers and scientists from CenUSA Objectives 1 (*Feedstock Development*), 2 (*Sustainable Feedstock Production Systems*, and 9 (*Extension and Outreach*), including CenUSA colleagues David Laird, Rob Mitchell, Jill Euken, Chad Hart, and Sorrel Brown. The ICM presentation will address the economics of a system of perennial grasses and administer a survey to gauge participants' thoughts on the likely barriers and drivers of implementation.

Collaboration with industry and business model development:

- Co-Project Director Dermot Hayes indicates:

> *I am part of a group that is interacting with Du Pont, Deere and Stine seeds on a project to model the use of feedstocks as a fuel source for fast pyrolysis. The fast pyrolysis system would be distributed and would provide a char byproduct. The group includes soil scientists, chemical engineers and mechanical engineers. This project has now evolved to the point where we have begun to construct a business model. The model involves the sale of bio-oil for use in furnaces for heat. Used in this manner the bio-oil will qualify for credit as a* cellulosic *biofuel. The char will be sold as a soil amendment to improve water holding capacity and ion exchange on eroded land or thin soils. Initial results suggest that the product has the potential to permanently improve soil quality.*
>
> *I am* also *working with an economist at Indiana University to model the aggregate supply curve for switchgrass, wheat straw and corn stover. The results suggest that corn stover will supply enough biomass to meet the cellulosic fuel mandates before any of the other possible sources become economical.*

5. Plans for Next Quarter

During the second quarter year 2 (Q2 Y2), our team will work towards accomplishing the following:

- Deliver a session at the 2012 ICM CenUSA Bioenergy Symposium, titled, *Understanding the economics of a system of perennial grasses for bioenergy in the central U.S.* (Jacobs).
- Report the findings of the survey administered during the ICM event (Jacobs).
- Continue to push forward on the goal of accessing farm-level CRP data (Jacobs).
- Interact with industry (Du Pont, Deere, and Stine Seeds) on a project to model the use of feedstocks as a fuel source for fast pyrolysis. The business model involves a distributed system of fast pyrolysis that provides as byproducts char and bio-oil. Char will be sold as a soil amendment, and bio-oil will be sold for use in furnaces for heat. The group includes soil scientists, chemical engineers and mechanical engineers (Hayes).

- Model the aggregate supply curve for switchgrass, wheat straw, and corn stover (Hayes).

6. **Publications, Presentations, and Proposals Submitted**

None.

Objective 7. Health & Safety

The production of bioenergy feedstocks will have inherent differences from current agricultural processes. These differences could increase the potential for workforce injury or death if not properly understood and if effective protective counter measures are not in place.

The Health and Safety team addresses two key elements in the biofuel feedstock supply chain:

- The risks associated with producing feedstocks; and
- The risks of air/dust exposure.

1. **Task 1 – Managing Risks in Producing Feedstocks**

   a. **Planned Activities**

   The team expanded the collection of the various duties and responsibilities associated with producing feedstocks to be used in risk assessments for hazards. The development of the procedural process for identifying, analyzing, and grouping tasks was continued. The team also began the collection of various injury data sources to be used in the analysis of frequency and severity of agricultural injuries associated with task of producing feedstocks.

   b. **Actual Accomplishments**

   More items have been added to the list of identified duties and responsibilities for determining the risk involved. Refinement in the group methodology is being considered because of the different types of individual tasks connected with duties and responsibilities associated with producing feedstocks. First examination of preliminary injury data sources to be used in the risk assessment was conducted and a change in the procedure of measuring the risk might be needed because of available data.

   c. **Explanation of Variance**

   No variance has been experienced and accomplishments are on schedule.

   d. **Plans for Next Quarter**

Refinement of the accumulated listing of duties and responsibilities will continue. Risk assessment protocol for handling the evaluation of the various tasks will continue. The continued evaluation of the various injury data sources that links available injury data to identified tasks will move toward completion.

e. Publications, Presentations, and Proposals Submitted

Previous publication submitted: Schwab, C. V., and M. Hanna. “Master Gardeners’ safety precautions for handling, applying, and storing biochar.” CenUSA Bioenergy 2012 Publication. ISU University Extension and Outreach, Ames, IA 50011.

2. Task 2 – Assessing Primary Dust Exposure

a. Planned Activities

Initial locations where dust exposures are starting to be identified and those identified from Task 1 above are being included.

b. Actual Accomplishments

Several initial locations for dust exposures were logged and several more were explored in the first quarter of project year 2.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

We will continue to find more potential locations of dust exposure. Appropriate monitoring equipment will be identified and obtained to conduct the pilot study. Approvals and procedures will be established.

e. Publications, Presentations, and Proposals Submitted

None to report this period.

OUTREACH AND EXTENSION

Objective 8. Education

The Education Objective seeks to meet the future workforce demands of the emerging Bioeconomy through two distinct subtasks as follow:

- To develop a shared bioenergy curriculum core for the Central Region, and

- To provide interdisciplinary training and engagement opportunities for undergraduate and graduate students.

Subtask 1 focuses on curriculum development. Subtask 2A involves training undergraduate students via an 8-week summer internship program modeled on the highly successful NSF REU (research experience for undergraduates) program.

Subtask 2B involves training graduate students via a 2-week summer intensive program modeled on a highly successful industry sponsored intensive program in biorenewables the team led in 2009.

Subtask 1: Curriculum Development

1. **Planned Activities**

- **Module 1. Perennial Grass Physiology, Growth, and Development**
  - ✓ **Seed Structure/Seedling Emergence Activity**. Make publically available and submit to *Journal of Natural Resources and Life Sciences Education* (*JNRLSE*) for peer review.
  - ✓ **Tiller Structure Text-based Lesson**. Make publically available and submit to *JNRLSE* for peer review.
- **Module 2. Perennial Grass Establishment and Management**
  - ✓ Complete components and submit to internal review/*JNRLSE.*
- **Module 3. Harvesting Systems for Bioenergy Grasses**
  - ✓ Complete components and submit to internal review/*JNRLSE.*
- **Module 4. Storage Systems for Bioenergy Grasses**
  - ✓ Complete outline of module content.
- **Modules 5 and 6. Markets & Distribution Modules** (lead authors Nicole Olynk and Corrine Alexander)
  - ✓ Complete content outlines and begin development of activities with Amy Kohmetscher.

2. **Actual Accomplishments**

- Identified specific evaluation goals and developed initial tools for evaluating modules in off-line environments (Evaluation lead: Gwen Nugent)

- Attended workshop on Americans with Disabilities Act compliance of on-line materials. We will adapt new practices that improve accessibility of module activities for differently-abled students.

- **Module 1. Perennial Grass Physiology, Growth, and Development.** Status of components (Lead author John Guretzky):

  ✓ **Seed Structure/Seedling Emergence** activity. Reviewed and evaluated by students in UNL *Forage Crop and Range Management* course.

  ✓ **Tiller Structure Text-based Lesson**. Reviewed and evaluated by students in UNL *Forage Crop and Range Management* course.

- **Module 2. Perennial Grass Establishment and Management.** Status of components (Lead author John Guretzky):

  ✓ Completed lessons on drill calibration and establishment grid usage.

  ✓ Pure Live Seed lesson reviewed and evaluated by students in UNL *Forage Crop and Range Management* course.

- **Module 3. Perennial Grass Harvest Management**. Status of components (Lead authors Pat Murphy and Iman Beheshti Tabar):

  ✓ Added content related to winowing and baling equipment.

  ✓ Added animations demonstrating mower-conditioning and baling from equipment manufacturers with copyright permission.

  ✓ Students reviewed and evaluated module in Purdue Crop Production Equipment course.

- **Module 4. Storage Management.** Status of components (Lead authors Pat Murphy and Iman Beheshti Tabar):

  ✓ Completed outline of module content.

- **Module 5. Integrating Bioenergy Production into Current Systems**. Status of components **(**Lead author Nicole Olynk):

  ✓ Completed development of content in PowerPoint.

- **Module 6. Markets & Distribution Module**. Status of components (Lead author Corrine Alexander):

- ✓ Completed outline of module content.

- **Module 7. Introduction to Perennial Grasses as a Bioenergy Feedstock**. Status of components (Lead author John Guretzky):

  - ✓ Converted CenUSA Co-Project Director Ken Vogel's webinar into lesson.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- **Module 2.** Perennial **Grass Establishment and Management**
  - ✓ Complete internal review and submit to *JNRLSE* for peer review.
- **Module 3. Perennial Grass Harvest Management**
  - ✓ Complete internal review and submit to *JNRLSE* for peer review.
- **Module 4. Storage Management**
  - ✓ Develop module content in PowerPoint and begin module development activities with Amy Kohmetscher.
- **Module 5. Integrating Bioenergy Production into Current Systems**
  - ✓ Complete module development activities with Amy Kohmetscher.
- **Module 6. Markets & Distribution Module**
  - ✓ Complete development of content in PowerPoint and begin module development activities with Amy Kohmetscher.
- **Module 7. Introduction to Perennial Grasses as a Bioenergy Feedstock**
  - ✓ Complete outline of remaining content.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Subtask 2A: Training Undergraduates via Internship Program

1. Planned Activities

- Six students placed at partner institutions (Purdue University, University of Nebraska, Lincoln, and the USDA Eastern Regional Research Center in Wyndmoor, Pennsylvania) will return to Iowa State University for the conclusion of the program.
- All student interns will travel to Mead, Nebraska, to visit the University of Nebraska's Agricultural Research and Development Center (ARDC). Field plots tours will showcase all aspects of management, production, sustainability, breeding, and basic biology research. Rob Mitchell and Ken Vogel will lead the demonstrations and tours with help from other CenUSA team members.
- All CenUSA student interns will participate in the ISU university-wide undergraduate research poster session and reception. This poster session, the culminating event of the CenUSA Bioenergy Internship Program, will include all undergraduate research interns who have participated in summer research internships at Iowa State University. This event will showcase research projects conducted by over 100 students.
- All students will complete a post-program survey conducted by Iowa State University's Research Institute for Studies in Education (RISE). The purpose of this assessment is to (1) assess the program's activities; (2) evaluate immediate program successes and challenges; (3) promote continued interest in the program by alumni after they complete their research experience; and (4) track the career paths of our graduates.
- Finalize and process all payments related to the internship program. Coordinate with Purdue University to insure all relevant payments for students placed on Purdue funds were accomplished.
- Make a plan for student placements and begin soliciting faculty hosts for the summer 2013 program.
- Create a calendar and content outline for the summer 2013 program.

2. Actual Accomplishments

- Interns at partner institutions returned to Iowa State University for program conclusion.
- Interns visited the University of Nebraska's Agricultural Research and Development Center (ARDC) and participated in tours.
- Interns participated in the ISU university-wide undergraduate research poster session and reception.
- Interns completed post-program survey.

- All internship-relevant payments processed except for one with a partner institution where there's been a delay in getting the bill from their housing department.
- Soliciting faculty hosts for the summer 2013 program.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Finish solicitation of projects from faculty.
- Determine distribution of students to sites, that is, determine the number of slots for each participating lab.
- Promote the undergraduate internship program and encourage application submissions, working with lists of underrepresented minority students generated by ISU graduate college, and through job-posting boards at regional institutions.
- Migrate program website to primary CenUSA host, rather than independent site (ISU ABE) used for inaugural year.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Subtask 2B – Training Graduate Students via Intensive Program

1. Planned Activities

- Meet with CenUSA Project Director and key Objective leaders to determine when to conduct the Intensive Program (e.g., early summer or in conjunction with the annual meeting in August 2013).
- Create detailed schedule for inaugural Intensive Program for graduate students.
- Contact CenUSA faculty members and secure their involvement and participation.

2. Actual Accomplishments

- Met with CenUSA Project Director and key Objective leaders to determine when to conduct the Intensive Program – established that this should occur in second week of June 2013 at the ISU campus.
- Created a detailed draft schedule for inaugural Intensive Program for graduate students.

- Contacted CenUSA faculty members. Well over half have made commitments of time; some have indicated concerns about scope of their portion, and we have adjusted schedule accordingly.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Get tentative headcount from entire program.
- Finalize schedule.
- Get clear learning objectives for each day of content from program lead.
- Line up housing and facilities for program.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Objective 9. Extension and Outreach

The Extension and Outreach objective serves as CenUSA's link to the larger community of agricultural and horticultural producers and to the public-at-large. The team delivers science-based knowledge and informal education programs linked to CenUSA Objectives 1-7.

The following teams conduct the Outreach and Extension Objective's work:

- **Extension Staff Training/eXtension Team**

  This team concentrates on creating and promoting professional development activities for Extension educators and agricultural and horticultural industry leaders.

- **Producer Research Plots/Perennial Grass Team**

  This team covers the areas of:

  ✓ Production, harvest, storage, transportation;

  ✓ Social and community impacts;

  ✓ Producer and general public awareness of perennial crops and Biochar agriculture; and

  ✓ Certified Crop Advisor training.

- **Economics and Decision Tools Team**

  This team focuses on the development of crop enterprise decision support tools to analyze the economic possibilities associated with converting acreage from existing uses to energy biomass feedstock crops.

- **Health and Safety Team**

  This team integrates its work with the Producer Research Plots/Perennial Grass and the Public Awareness/Horticulture/eXtension 4-H and Youth teams (See Objective 7. Health and Safety).

- **Public Awareness/Horticulture/eXtension 4-H and Youth Team**

  This team focuses on two separate areas:

  - **Youth Development** – The emphasis is on developing a series of experiential programs for youth that introduce the topics of biofuels production, carbon and nutrient cycling and biochar as a soil amendment.
  - **Broader Public Education/Master Gardener Program** – The goal is to acquaint the non-farm community with biofuels and biochar through a series of outreach activities using the highly successful Master Gardener volunteer model as the means of introducing the topics to the public.

- **Evaluation/Administration Team**

  This team coordinates CenUSA's extensive extension and outreach activities. The team is also charged with developing evaluation mechanisms for assessing learning and behavior change resulting from extension and outreach activities, compiling evaluation results and preparing reports, and coordination of team meetings.

1. Extension Staff Training/eXtension Team

a. Planned Activities

- Provided three presentations at *Crop Management Diagnostic* Clinics in Nebraska.
- Development, review, posting and publication of Extension publications related to switchgrass establishment, switchgrass weed control, switchgrass nutrient management, and optimizing harvests of perennial grasses.
- Establish eXtension Farm Energy Image gallery.

b. Actual Accomplishments

- **Public Presentations**. Gave three presentations (60 crop consultants, extension educators and producers) at *Crop Management Diagnostic* Clinics in Nebraska.

- **Fact Sheets**. Switchgrass Establishment (Fact Sheet 1.1) has been drafted and is in final review; Switchgrass Weed Control (Fact Sheet 2.1) has been drafted and is in review; Switchgrass Nutrient Management (Fact Sheet 2.2) has been drafted and is in review; Optimizing Harvest of Perennial Grass (Fact Sheet 3.1) has been drafted and is in review.

- **Video Productions**. "Optimizing Harvest of Perennial Grass" has been produced and is being edited.

- Extension Farm Energy Image gallery completed and tested, now ready for image uploading by CenUSA collaborators (http://farmenergymedia.extension.org/images.

c. Explanation of Variance

Not applicable.

d. Plans for Next Quarter

- **Public Presentations**. Three presentations are scheduled for a large farm machinery show related to bioenergy/biofuels/switchgrass to be held in Nebraska.

- **Fact Sheets.** We will continue to work on fact sheets and video listed in the "Actual Accomplishments" section, above.

e. Publications, Presentations, and Proposals Submitted

- Deanna Namuth-Covert, Ashu Guru, Michael Fairchild, Amy Kohmetscher, Deanna Leingang, Carol Speth, Jamie Sherman, Don Lee, Martha Mamo, Mary Brakke, John Guretzky, and Patrick Murphy. "Learning Object Repository Becomes of Age – Reflecting on 13 Years of Faculty Development and Technology Applications." Presentation, 18th Annual Sloan International Conference on Online Learning: University of Nebraska-Lincoln, Montana State University, University of Minnesota and Purdue University, October 12, 2012.

- Gave three presentations for 60 crop consultants, extension educators, and producers at the Crop Management Diagnostic Clinics. CenUSA Extension and Outreach collaborator Keith Glewen was responsible for planning the event. Co-presenters were CenUSA Co-Project Directors Rob Mitchell and Ken Vogel.

2. Producer Research Plots/Perennial Grass Team

a. Planned Activities

- *Switchgrass for Bioenergy Crop* Clinic at University of Nebraska
- Evaluation of on-farm perennial grass demonstrations in Iowa, Nebraska, Minnesota, and Indiana.
- Perennial Grass Field Day at the Phil Winborn family farm (Kalona, IA)

b. Actual Accomplishments

- Held a One-day *Switchgrass for Bioenergy Crop* Clinic at the University of Nebraska attended by 34 crop consultants and producers from Nebraska, Minnesota, Missouri, Kansas, and South Dakota. The producers reported farming a total of 28,710 acres and the attending consultants described impacting 966,671 acres.

  ✓ 83 percent of participants reported major or significant improvements in their understanding of potential fuel yields from perennial grasses (gal/ton).

  ✓ 72 percent of participants reported major or significant improvement in their understanding of switchgrass basic agronomic practices.

  ✓ 72 percent of participants reported major or significant improvements in their understanding of land types on which switchgrass and other perennial grasses have economic potential as bioenergy crops.

  ✓ 62 percent of participants reported major or significant improvement in their understanding of the potential for genetic improvements in switchgrass for bioenergy.

  ✓ 65 percent of participants reported major or significant improvement in their understanding of biomass storage requirements.

  ✓ 59 percent of participants reported major or significant improvement in their understanding of environmental benefits of growing perennial grasses as bioenergy crops.

  ✓ 45 percent of participants reported they would expand and/or modify what they are already recommending regarding switchgrass and other perennial bioenergy grasses if a biomass biorefinery is built in their area, as a result of their attendance at the crop clinic.

- ✓ 48 percent of participants reported they would and/or modify their recommendations regarding perennial warm-season grasses for hay or pasture to spread production risks as a result of the crop clinic.

- Field days at on-farm demonstration plots in Iowa and Minnesota were cancelled due to poor establishment of switchgrass in 2012 (result of early torrential rains and summer drought).

- Deployed "grid method" to evaluate stand establishment of switchgrass prior to frost to determine what rescue treatments of the plots would be required in Indiana, Iowa, Nebraska, and Minnesota in 2013.

- Developed the concept for the CenUSA bioenergy exhibit and worked through several edits to the exhibit.

c. Explanation of Variance

Planned field days were cancelled in Iowa and Minnesota due to poor establishment of the project demonstration plots.

d. Plans for Next Quarter

- Recruit farmers for second set of on-farm demonstration plots to be established in Indiana, Iowa, Nebraska, and Minnesota in the spring of 2013.

- Meet with Minnesota Corn Growers to discuss CenUSA project objectives and challenges associated with switchgrass establishment on marginal lands.

- Plan for field days to be held in June 2013 in Indiana and Iowa.

- Work with Purdue Exhibit Center to continue development of CenUSA Bioenergy Grass exhibit.

b. Publications, Presentations, and Proposals Submitted

None to report.

3. Economics and Decision Tools Team

a. Planned Activities

- **Iowa Team**. Identify and develop sessions regarding perennial bioenergy grass economics and producer interest for the *Iowa Integrated Crop Management* (ICM) Clinic.

- **Minnesota Team**. Developing spreadsheet of overall costs/gallon relative to conventional gasoline.

b. Actual Accomplishments

- **Iowa Team**. "CenUSA mini series" entitled ***Sustainable Bioenergy Symposium*** with presentations by four CenUSA researchers/extension leaders will be offered at the ISU ICM Clinic. See: http://www.aep.iastate.edu/icm/workshops.html#cenusa.

- **Minnesota Team**. (MN) Developing spreadsheet of overall costs/gallon relative to conventional gasoline.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

- **Iowa and Nebraska**. CenUSA information will be incorporated into Extension winter meetings

- **Minnesota**. Awareness talk or paper on the spreadsheet of overall costs/gallon relative to conventional gasoline.

- **Indiana**. Indiana Biomass Energy Working Group meeting to be held January 8, 2013 in which the topic of discussion will be the research and market emergence for Aviation Biofuels. Speakers will include not only CenUSA project faculty, but also policy experts, and aviation industry professionals.

- **Indiana**. Hosting Indiana Small Farms Conference March 1 - 2, 2013, in which there will be a session devoted to CenUSA and utilization of marginal crop and grasslands for biofuel energy crop production.

e. Publications, Presentations, and Proposals Submitted

None to report this period.

4. Health and Safety

a. Planned Activities

None this quarter.

b. Actual Accomplishments

None this quarter.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

None for the next quarter.

e. Publications, Presentations, and Proposals Submitted

None for the next quarter.

5. Public Awareness/Horticulture/eXtension 4-H and Youth Team

5.A – Youth Development

a. Youth Development – Planned Activities

- **Indiana**. Ordering and gathering supplies and curricular materials for 3rd grade, 8th grade, and Indiana high school classrooms interested in learning about biochar in the classroom through plant and soil science.
- **Indiana**. Generate six to seven counties interested in implementing education program in 3rd grade classrooms all around Indiana.
- **Indiana**. Two 8th grade science classrooms in an urban Lafayette, Indiana junior high school interested in biochar-related classroom activities, moving forward with one (implementation will be in November 2013), another will move forward as soon as supplies are gathered. A high school classroom in urban Indianapolis, Indiana with extremely at-risk youth is interested in implementing biochar-related science education.

b. Youth Development – Actual Accomplishments

- **Indiana**. Began educating 8th grade youth about biochar and soil chemistry at Indiana urban junior high school.
- **Indiana**. Introduced the concepts of pyrolysis and the products of biogas, bio-oil, and biochar.
- **Indiana**. Also introduced the concept of increasing the carbon content of soils to potentially increase yields in crops, as well as the carbon sequestration potential of biochar.

- **Indiana**. Began ordering and gathering supplies and curricular materials for 3rd grade, 8th grade, and high school classrooms for interested parties.
- **Indiana**. Confirmed participation of urban high school with at-risk youth in Indianapolis.
- **Indiana**. Reviewing draft of ISU developed Biochar educational curriculum. Reviewing for safety, effectiveness and appropriateness of approach.

c. Youth Development – Explanation of Variance

- **Indiana**. Emphasis in Indiana was on recruitment this quarter rather than curriculum review. This was due to the CenUSA graduate student having the opportunity to teach in an 8th grade classroom once a week as part of an academic professional development course.
- **Indiana**. Space constraints in classrooms required the evaluation of multiple options for plant light setups crucial to growing plants in the classroom.
- **Indiana**. Undergraduate worker situation has yet to be resolved. We are working on finding a reliable individual.

d. Youth Development – Plans for Next Quarter

- **Indiana**. Hold Junior Master Gardener training with focus on how existing activities can be adapted to include discussions of biochar and biofuels.
- **Indiana**. Pilot test evaluation instruments for education programs to assess their validity and reliability.
- **Indiana**. Implementation of plant and soil science lessons focused on biochar in two 8th grade urban junior high school classrooms.
- **Indiana**. Implementation of plant and soil science lessons in an urban high school classroom with at-risk youth.
- **Indiana**. Implementation of plant and soil science lessons in 3rd grade classrooms across Indiana with the assistance of Purdue Extension Educators.
- **Iowa**. Recruit 4-H groups to partner with Master Gardeners for spring planting of biochar demonstrations based on the developed K-12 curriculum and adapted for use in a non-formal setting. Promote with K-12 formal educations as well.

e. Youth Development – Publications, Presentations, and Proposals Submitted

None to report this period.

5.B – Broader Public education/Master Gardener Program

a. Broader Public Education/Master Gardener Program – Planned Activities

- **Iowa and Minnesota**. Collect yield and quality data from biochar demonstration gardens.
- **Minnesota**. Host display at Northern Threshing Show.

b. Broader Public Education/Master Gardener Program – Actual Accomplishments

- **Iowa and Minnesota**. Data has been collected and is in process of being analyzed.
- **Minnesota**. Display at Northern Threshing Show.

c. Broader Public Education/Master Gardener Program – Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Broader Public Education/Master Gardener Program – Plans for Next Quarter

- Establish initial Master Gardener biochar demonstration gardens. All sites are on schedule for planting.
- **Minnesota**. Evaluation will be created and sent to Master Gardener volunteers involved in biochar gardens in 2012 to get their feedback from this first year's experience.
- **Iowa and Minnesota**. Assessments will be made on the data collection over the next 2 months. Master Gardener volunteer recruitment of 2013 will take place in January-February, 2013.
- **Iowa and Minnesota**. Assessments will be made from the fall 2012 soil tests.
- **Minnesota**. Julie Weisenhorn will be meeting with a new Master Gardener group from the Fond du Lac Tribal community on November 27, 2012 to establish a new biochar research plot in an existing community garden that will replicate the three plots already located in the Twin Cities. The soil at this site has low pH and is a mixture of sand and rocks. A soil test will be taken before amending the site in the spring.

e. Broader Public Education/Master Gardener Program – Publications, Presentations, and Proposals Submitted

- Byers, Becky. “Biochar, Bio-benefits?” Solutions, *University of Minnesota College of Food, Agricultural and Natural Resource Sciences* (Fall 2012). http://www.cfans.umn.edu/Solutions/Fall2012/Biochar/index.htm.

6. Evaluation/ Administration Team

a. Evaluation/ Administration Team – Planned Activities

- Hold breakout session on evaluation tools at CenUSA annual meeting for CenUSA Extension Team members.
- Review CenUSA Extension evaluation protocols and instruments developed by CenUSA Extension team member Sorrel Brown, and ask for feedback.
- Revise protocols and instruments based on feedback.

  Revise evaluation instruments based on feedback.
- Write final CenUSA Extension components for CenUSA quarterly reports and the 2013 annual report.
- Negotiate and finalize Year 2 Extension budgets.
- Participate in CenUSA Extension team meetings/webinars.
- Plan CenUSA workshop to address weakness identified by USDA program managers. Workshop will include representatives of thermochemical conversion companies, producer groups, elected officials and economic development professionals, CenUSA team members and advisory board members.

b. Evaluation/ Administration Team – Actual Accomplishments

- Evaluation protocols and instruments were reviewed at the annual meeting; adjustments were made, meetings held with individual and groups of CenUSA Extension team members to plan evaluation for 2013 programs.
- Reports were prepared.
- A workshop, **Roadmap to Commercialize Thermochemical Biofuels and Bio-Products Processing in the Midwest,** has been planned for December 11-13, 2012.

c. Evaluation/Administration Team – Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Evaluation/ Administration Team – Plans for Next Quarter

- Continue development and analysis of evaluations for CenUSA workshops.
- Continue to work with Extension teams to plan, develop, and implement CenUSA Extension programs.
- Host workshop **Roadmap to Commercialize Thermochemical Biofuels and Bio-Products Processing in the Midwest**, December 11-13, 2012.

e. Evaluation/ Administration Team – Publications, Presentations, and Proposals Submitted

- None to report this period.

cenusa bioenergy

"Our vision is to create a regional system for producing advanced transportation fuels derived from perennial grasses grown on land that is either unsuitable or marginal for row crop production. In addition to producing advanced biofuels, the proposed system will improve the sustainability of existing cropping systems by reducing agricultural runoff of nutrients and soil and increasing carbon sequestration."

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Exhibit 17

cenusa bioenergy

Quarterly Progress Report

Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform

February 2013

Agriculture and Food Research Initiative Competitive Grant
No. 2011-68005-30411

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NOTICE

This quarterly report was prepared by Iowa State University and CenUSA Bioenergy research colleagues from Purdue University, United States Department of Agriculture-Agricultural Research Service, University of Illinois, University of Minnesota, University of Nebraska, Lincoln, University of Vermont, and the University of Wisconsin in the course of performing academic research supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the United States Department of Agriculture National Institute of Food and Agriculture ("USDA-NIFA).

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Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (AFRI-CAP 2010-05073)

Quarterly Report: November 1, 2012 – January 31, 2013

PROJECT ADMINISTRATION

1. Project Organization and Governance Accomplishments

Ken Moore (Professor, Iowa State University) is the CenUSA Bioenergy Project Director. Anne Kinzel (Chief Operating Officer) and Val Evans (Financial Manager) handle project administration and business affairs, including project coordination, communication, and data sharing among institutions across the states. In addition, Kinzel is responsible for the day-to-day project management including the preparation quarterly and annual progress reports, meetings, and maintenance of the project's public face (website/social media outlets). Evans continues to be responsible for all project financial activities, including the development and implementation of administrative policies and procedures to ensure effective financial operation and oversight of the project.

As we enter the midpoint of our second year of CenUSA activities we are confident that each of the nine CenUSA objectives is showing satisfactory progress towards meeting CenUSA's deliverables schedule. This quarter has seen a number of important activities take place. We have featured a few to discuss in this project organization and governance section as they involve all objectives working together towards our project goals.

Featured Second Quarter Activities

- **Workshop: Roadmap to Commercialize Thermochemical Biofuels and Bio-Products Processing in the Midwest**

  The workshop *Roadmap to Commercialize Thermochemical Biofuels and Bio-Processing in the Midwest* was held December 11-12, 2012 at Iowa State University in Ames, Iowa. CenUSA, the ISU Bioeconomy Institute, the USDA Central-East Regional Biomass Research Center, Iowa NSF EPSCoR, and the Iowa Energy Center sponsored the workshop (See Exhibit 1. Workshop Agenda and Attendee List).[1]

  Workshop Focus: Optimal Feedstocks and Commercial Pathways. The workshop had three primary goals:

  1. Foster relationships between CenUSA researchers, other interested faculty, Midwest agricultural producer groups, and the thermochemical processing industry.

[1] Iowa EPSCoR is funded by grant number EPS-1101284 from the National Science Foundation. Information is available at http://iowaepscor.org/

2. Identify optimal biomass feedstock characteristics for thermochemical processing of biomass.

3. Identify commercial pathways for thermal chemical processing of herbaceous biomass to in the Midwest region.

Beyond these broad goals we designed the program to focus on the following objectives:

1. Identifying commercial pathways for thermochemical technologies in the Midwest.

2. Providing a forum for representatives leading companies in commercialization of thermochemical processing of biomass to share their technologies, goals, desired type of feedstock, and amount of biomass needed for commercial operation.

3. Providing a panel of experts on plant breeding and agronomy to describe how different agricultural approaches can be used to optimize the yield of biomass feedstocks while minimizing undesirable components such as ash, nitrogen, and moisture.

4. Having experts from Iowa State University and the USDA discuss non-fuel products such as heating oil, biochar, and bioasphalt that can be made by thermochemically processing biomass.

5. Bringing together representatives from agricultural producer groups to describe to industry representatives and academic researchers how they brought past bioenergy projects to fruition and their criteria for new projects.

Tables 1, 2 3 and 4 show the technologies and attendees represented at the workshop.

Table 1. Technologies Represented	
ADM	Acetic Acid Pulping
BP	Gasification
Chevron	Solvent Liquifaction
GTI	Pyrolysis
KiOR	Catalytic Pyrolysis
ICM	Gasification
P66	Pyrolysis
Renmatix	Solvent Liquifaction
UOP	Pyrolysis
Virent	APR/ Catalytic

Workshop Methodology. Jill Euken (CoPd Extension and Outreach) and Anne Kinzel worked with Andrew Larson (ISU SARE Coordinator) on a workshop plan. With the participants' diverse backgrounds and broad range of technical competence, we wanted to find the best method for participants to share their thoughts as quickly and as expansively as possible. With Larson's expertise we were able to put together an entire workshop script devoted to interaction (See Exhibit 2. CenUSA Facilitated Discussion).

Table 2. Industry Representatives	
Rod Backhaus	Producer - Tall Corn Ethanol
Manuk Colakyan	Renmatix
Bill Couser	Lincolnway Energy
Bob Freeman	Frontier Labs
Paula Hassett-Flowers	UOP
Andrew Held	Virent
Mark Hughes	P66
Byron Johnson	P66
Dmitry Kazachkin	Renmatix
Paul Keeney	Producer - KAAPA
Mark Laurenzo	Producer - IDEA
Frank Lipiecki	Renmatix
Terry Marker	GTI
Peter Metelski	BP
Brad Petersburg	Producer - Ag Ventures Alliance
Magdalena Ramirez	KiOR
Howard Roe	Producer - Tall Corn Ethanol
Bob Rozmiarek	Virent
Rusty Schmidt	Producer - Ag Ventures Alliance
Harry Stine	Producer - Stine Seeds
Jeff Stroburg	Producer - West Central Coop
Rod Williamson	Iowa Corn Growers
Michelle Young	Chevron

Table 3. CenUSA Advisory Board	
Bert Bennett	ICM
Tom Binder	ADM & Advisory Board Chair
Denny Harding	Iowa Farm Bureau
Bryan Mellage	Mellage Truck & Tractor/ C-Minus
LaVon Schiltz	Nevada Economic Development Council
John Weis	Agricultural Producer

Table 4. Academic Attendees: Professional Specialty and Interest	
Sorrel Brown	CenUSA Co-PD & Evaluation Specialist (ISU/Agronomy)
Mike Casler	CenUSA Co-PD – USDA ARS
Kendall Lamkey	Agronomy (ISU)
David Laird	CenUSA Co-PD (ISU/Agronomy)
Thomas Lubberstedt	Director, ISU Baker Center for Plant Breeding
Ken Moore	CenUSA PD (ISU/Agronomy)
Marty Schmer	USDA (ARS/Agronomy)
Ken Vogel	CenUSA Co-PD (ARS/Plant Geneticist)
Chris Williams	CCEE (ISU)
Mark Wright	Mechanical Eng. (ISU)
Stuart Birrell	CenUSA Co-PD (ISU/Ag. & Bio Eng.)
Robert Brown	Mechanical Eng. (ISU)
Laura Jarboe	Chemical & Biological Eng. (ISU)
Rob Mitchell	CenUSA Co-PD & USDA - ARS
Raj Raman	CenUSA Co-PD (ISU/Ag. & Bio Eng.)
Jeff Volenec	CenUSA Co-PD (Purdue/Agronomy)
Dermot Hayes	CenUSA Co-PD (ISU/Ag. Economist)
Keri Jacobs	CenUSA Co-PD (ISU/Ag. Economist)

Workshop Outcomes. Our script did yield lively interaction between the participants which was well captured in the *Roadmap to Commercialize Report* (See Exhibit 3. Roadmap to Commercialization Report), and in the Workshop Evaluation Report (See Exhibit 4. Workshop Evaluation Report). The responses in the *Roadmap to Commercialization Report* demonstrates the participants were very engaged with each other and willing to offer many thoughtful suggestions and observations.

The workshop's key takeaway points include:

- The thermochemical industry is moving towards commercialization and is robust enough to handle diverse feedstocks.
- Agronomic practices can be improved by collecting and processing cellulosic material.
    - Stover collection is needed on some fields
    - Biochar addition improves soil and yields

- The fact that a vast array of companies and individuals are working towards the same goal creates an atmosphere for things to get done.

- There is farmer cooperative interest in partnering with and supplying the thermochemical industry.

Participants also made the following key recommendations:

- Create a multi-industry consortium, develop a shared vision, promote R&D, etc. to widely engage geographically diverse supply chain and stakeholders groups.

- Promote education and communication between producers and industry so that risks are understood and options can be developed to address risk.

- Look at vertical integration that identifies the specifics of the processes that need improvement.

Key Post-Workshop Follow-Up Actions. As we had hoped, the workshop helped create some new working relationships between the CenUSA research team, agricultural producer industry participants. These enhanced relationships yielded these promising results:

- **Participation in the 2013 CenUSA Annual Meeting**. Based on comments and suggestions made during the workshop we will be inviting selected participants to take part in the 2013 CenUSA Bioenergy Annual Meeting (July 30 - Aug. 2, 2013). This will provide further opportunity for interactions between CenUSA researchers and industry. We are aware that industry representatives are especially interested in the meeting's field tours which will be conducted at Purdue University facilities and sites near West Lafayette, Indiana. Complete information regarding this meeting is provided in Section 1.a below.

- **Environmental Interest Group Workshop**. CenUSA will host a workshop in Minnesota for environmental interest groups in the summer or fall of 2013. CenUSA CoPd Jason Hill (System Performance Metrics, Data Collection, Modeling Analysis, and Tools) will lead this effort. Hill will also apply for a USDA-NIFA conference grant to support the event. This meeting was a direct outcome from discussions that took place at the CenUSA Bioenergy mid –year meeting that took place immediately following the Commercialization Workshop.

- **Data and Material Sharing**. Based on the participants' comments and observations from the CenUSA research team, we prepared a brief survey to share with industry participants (See Table 5 and "CenUSA Planning & Collaboration Meeting"). The survey was sent out the second week of January 2013.[2]

Initial survey results have participants expressing interest in advancing the performance of herbaceous biomass in thermochemical processing by participating in one or both of the following activities:

- Testing Midwest-produced herbaceous biomass in their system, and
- Sharing data from prior tests with herbaceous biomass in their particular process.

Table 5. Post-Workshop Industry Survey
1. Would you be interested in testing herbaceous biomass materials produced in the Midwest in your bench or pilot processing equipment if the material is provided to you at no cost and is well characterized? * If you answer "no," please skip to question 6.
2.a. What quantity switchgrass feedstock would you need in order to conduct the tests? (In Tons)
2b. What quantity Indian Grass feedstock would you need in order to conduct the tests? (In Tons)
2c. What quantity Big Blue Stem feedstock would you need in order to conduct the tests? (In Tons)
2d. What quantity corn stover (single pass, clean) feedstock would you need in order to conduct the tests? (In Tons)
3. Please specify the acceptable particle size range
4. When would you like to receive the materials?
5. [Demographic Questions]
6. Has your company already conducted tests with herbaceous biomass in thermochemical processes? (If you answer "yes," please answer question 7 as well.)
7. Would you be willing to share information about how herbaceous biomass performed in your process and your wish list for characteristics to optimize performance in your system(s)?

Table 6. Initial Industry Survey Responses	
ADM	ASAP: CenUSA to provide small bales or 1 kg of each of the types of biomass. By 8/1/13 provide big bales of each of the types of biomass.
KiOR	By 4/30/13: CenUSA to provide Switchgrass, Indian Grass, and Big Blue Stem samples.
Catchlight	Has already conducted tests with herbaceous biomass and will provide CenUSA with their existing data.

[2] https://docs.google.com/spreadsheet/viewform?formkey=dGJuQ3RHZjhFOFFFVmh4SkFJRkZfX1E6MQ#gid=0

Workshop Evaluation. We were especially pleased with these evaluation findings:

- 85% of the evaluation respondents indicated their understanding of ideal feedstock characteristics for thermochemical processing had improved after attending the workshop

- 88% of respondents found the length "just right".

- 82% found the workshop's general technical content to be "about right."

a. CenUSA Planning & Collaboration Meeting – December 12-13, 2012

Immediately following the Roadmap Workshop, the CenUSA executive team met in Ames to discuss CenUSA commercialization and transdisciplinary opportunities. The discussions allowed the executive team to fully flesh out what they learned in the workshop. The discussion was made livelier as each of the CoProject directors presented their observations from the standpoint of their own individual disciplines and research interests. USDA-NIFA program contact Bill Goldner facilitated significant portions of the discussions and provided direction for the project's future.[3]

This meeting also provided the impetus for the post-meeting industry survey above. Participants agreed to work together to provide industry with the requested material.

a. Advisory Board

The Advisory Board continues to provide valuable feedback and advice to the research team. We invited selected Advisory Board members to the Roadmap Workshop. As they have throughout the project, the Advisory Board actively participated in the workshop.

New Board Member. In December 2012 board member Tim McCoy submitted his resignation. Due to a promotion he believed he was unable to devote sufficient time to CenUSA activities. McCoy, as a leading official at the Nebraska Game and Parks Commission, was our wildlife expert on the Board. At McCoy's suggestion we invited Eric Zach, Ag Program Manager at the Nebraska Game and Parks Commission to join the Board. Zach, who also has an extensive background Midwestern wildlife management agreed to join the Board in late January 2013. (See Exhibit 5. Eric Zach Bio)

2. Coordination, Collaboration, and Communication

- **Executive Team Meetings and CenUSA Research Seminar.** The Co-Project directors representing each of the nine objectives continue to meet monthly with Ken Moore, Anne

[3] National Program Leader, Sustainable Bioenergy, AFRI

Kinzel and Val Evans via online meetings held in CenUSA's dedicated Adobe Connect meeting room. The virtual meeting room allows for documents to be viewed by all participants, enhancing communications and dialogue between participants. Tom Binder, the Advisory Board chair also attends these meetings, to ensure there is an Advisory Board presence during these important project gatherings.

Starting in January 2013, we began holding the *CenUSA Research Seminar Series* to coincide with the monthly Co-Project director meeting. The Research Seminars are held in the CenUSA Adobe Connect meeting room immediately following the monthly executive team meeting.

Each seminar focuses on the work of a CenUSA objective. We begin the seminars with a 15-minute talk by a project Objective Co-project director followed by a 15-minute graduate presentation(s). The seminars conclude with 20 minutes of question and answer time.

Our first seminar will be held February 22, 2013 and will feature the Feedstock Development Objective. CoPd Mike Casler. Casler's presentation "Twenty years of switchgrass improvement to create a dedicated bioenergy crop" provide a summary of the progress made between 1992 and 2002 in Lincoln, NE and Madison, WI to improve biomass yield of switchgrass and concluded with how that work has a direct tie-in to the CenUSA research effort. Graduate students Emily Rude and Guillaume Ramstein's presentation, "Genomic selection to improve biomass yield of switchgrass" will review efforts to develop a genome-wide DNA-marker platform to improve the efficiency and rate of gain for increasing biomass yield of switchgrass.

- **Objective and Team Meetings.** All nine CenUSA Objectives continue participate in scheduled and ad hoc meetings using the CenUSA Adobe Connect meeting room or in face-to-face meetings. The five Extension and Outreach Objective teams also meet via Adobe Connect or face-to-face gatherings.[4]
- **2013 Annual Summit.** The advance planning for the 2013 annual summit is complete. The meeting will be held July 30 - August 2, 2013 in West Lafayette, Indiana. Jeff Volenec, Professor in the Department of Agronomy at Purdue University and Co-Project Director of CenUSA's Sustainable Feedstock Production Systems Objective, will host the 2013 Summit. We will be including an expanded roster of guests relative to our 2012 meeting. We have invited industry participants (See p. 6) and anticipate a strong contingent of graduate students now that our educational efforts are more fully underway.

[4] The teams are Broader Public/Master Gardener/Youth Programs, Economics and Decision Tools, Evaluation/Administration, Extension Staff Training/eXtension, Health and Safety, and Producer Research Plots/Perennial Grass. For more information see www.cenusa.iastate.edu/Outreach.

- **Communication Platforms.** CenUSA continues to focus on expanding the quality and sophistication of the CenUSA website (www.cenusa.iastate.edu) and other social media opportunities.

  The website has been upgraded and now features a redesigned home page. The home page provides a new "Events Calendar", and enhanced new ticker and improved "News" and "Collaborators" sections. These home page enhancements provide the public with better insight into the CenUSA project, and most importantly, the changes allow us to better promote CenUSA events and activities such as educational meetings, webinars, media events, eXtension bioenergy learning modules, field days, and networking opportunities.

  On the website's pass word-protected area we have a new calendar available to all CenUSA participants. The calendar is able to provide information on CenUSA meetings and helps the project stay organized.

  We have used a Twitter account (@CenUSAbioenergy) to provide project updates, and disseminate information regarding the availability of CenUSA publications. We continue to increase our number of Twitter followers within the biofuels/bioenergy community.

  Webinars/Videos. Our project webinars and videos are disseminated via three separate sites to provide multiple outlets to view CenUSA-webinars and videos: 1) the CenUSA website, 2) a CenUSA Bioenergy "YouTube Channel" (www.youtube.com/user/CenusaBioenergy) and 3) a CenUSA Bioenergy Vimeo site (https://vimeo.com/cenusabioenergy) to provide an additional outlet to view CenUSA webinars and videos.

  We added two videos to our sites this quarter:

  ✓ **How to Measure Stand Establishment Using a Grid** (December 28, 2012) CenUSA Bioenergy collaborator and University of Nebraska-Lincoln Extension Educator John Guretzky demonstrates how to use a grid to measure perennial grass stand establishment in this training video. (http://youtu.be/AXZN7-PmldU/ https://vimeo.com/55131669

  ✓ **Optimizing Harvest of Perennial Grasses for Biofuel** (January 18, 2013) CenUSA co-project director and University of Wisconsin professor Kevin Shinners discusses new systems to harvest, handle, store and transport perennial grasses that will be used as biomass feedstocks. Video produced by Pam Porter, University of Wisconsin Environmental Resources Center in partnership with the Division of Information Technology (available at http://youtu.be/NMt5Ct-65-Y and https://vimeo.com/57621501).

- **Financial Matters.** The Administrative Team continues to monitor all project budgets and subcontracts to ensure adherence to all sponsor budgeting rules and requirements.
- **Program Matters.** We will continue to focus on project coordination, communication, meetings and data sharing across Objectives, and on reaching the revised timelines milestones.

Germplasm to Harvest

Objective 1. Feedstock Development

Feedstock Development focuses on developing perennial grass cultivars and hybrids that can be used on marginal cropland in the Central United States for the production of biomass for energy. In 2012, the focus is on the establishment of new breeding and evaluation trials.

1. Significant Accomplishments Summary

CenUSA funding enabled the ARS breeding projects at Lincoln, Nebraska and Madison, Wisconsin to complete a third year of testing of previous established yields tests in three Midwest states. CenUSA funding also enabled this Objective's ARS-Lincoln project team to increase breeder seed under irrigation of a high-yielding, lowland type experimental switchgrass strain with very good winter hardiness that was identified in these trials. This strain, which has the experimental designation 'KxS HP1 NETO2 C1' has had excellent winter survival and high biomass yields throughout the region. In a trial near Spooner in northern Wisconsin, it had excellent winter survival and produced 11.7 Mg ha^{-1} biomass and had greater yields than all released cultivars in the trial. At Spooner, the lowland cultivar Kanlow and all Kanlow derived experimental strains winter killed. At DeKalb, Illinois, it produced 15.5 Mg ha^{-1} biomass, which was three Mg ha^{-1} greater than other cultivars in the trial. In eastern Nebraska, its average annual biomass yield for 2009 through 2011 was 18.1 mg ha^{-1} (8 tons/acre), which was 2.4 tons per acre greater than that of best available released upland cultivar. In 2012, 27 kg (60 lbs.) of breeder seed was produced which will be used to establish a Foundation Seed field under irrigation in 2013. The capability to produce seed under irrigation was critical in 2012 because of the severe drought. The University of Nebraska's Foundation seed division, *Husker Genetics*, will manage the Foundation seed production. The experimental strain is being processed for official release in 2013. It will be the first biomass type lowland cultivar that is well adapted to Midwestern winters (Ken Vogel, CenUSA Co-Pd/ARS-Lincoln and Mike Casler, CenUSA Co-Pd /ARS-Madison).

In addition to providing data to support the release of a new cultivar, the field trials and their analyses, which were completed in January 2013, produced some basic information documenting switchgrass breeding gains for biomass yield. The information gained is summarized below. This research is being prepared for publication (Ken Vogel and Mike Casler).

- **Breeding for Biomass Yield in Switchgrass.**

  ✓ Selection and breeding within WS4U upland switchgrass increased biomass yield by 4% per year for a simple phenotypic recurrent selection program that required only two years per generation.

  ✓ Selection for biomass yield and winter survival within Kanlow lowland switchgrass increased biomass yield by 2% per year. Because selection was conducted within USDA Hardiness Zone 5, the yield gains were successfully observed in other HZ5 locations, but not at locations within HZ3 or NZ4.

  ✓ Selection for biomass yield and winter survival within Kanlow x Summer hybrid populations resulted in third-generation populations with superior biomass yield and survivorship across HZ3 through HZ5, combining the best traits of both the upland and lowland parents. On average, the hybrid populations had 43% higher biomass yield than the better of the two parents, regardless of the location.

  ✓ All of the gains in biomass yield were associated with increases in biomass quality traits on a per-hectare basis, e.g. higher yield of ethanol per hectare and more combustible energy produced per hectare.

  ✓ Genetic increases in biomass yield were all measured at a constant amount of N fertilizer. As such, in the strictest sense of the term, all increases in biomass yield were a result of increased nitrogen-use efficiency (NUE). While N concentration of the biomass did not change as a result of selection, total N removed in the biomass increased in direct proportion to the increases in biomass yield. On average, each additional Mg/ha of biomass drew an additional 5-12 kg/ha of N from the soil.

- **Integrated Project Impact:**

  Because of the promising early results from these trials, the experimental strain KxS HP1 NETO2 C1 was included in all the regional small plot yield tests established in 2012 and in the CenUSA Objective *Sustainable Feedstock Production Systems* factor analysis trials, which were also established in 2012. All previous switchgrass management research in the Midwest has been conducted with upland cultivars developed primarily for use in pastures that have lower biomass yields. The data from these trials will be the first data for use in economic and system analyses for high yielding biomass type switchgrass adapted to the Midwest. All previous analyses have been done using data based on switchgrass cultivars developed for use in pastures. The biomass samples from these plots and trials also will be used in the CenUSA conversion research.

2. Planned Activities

- Biomass samples collected during the summer and autumn of 2012 will be dried, ground, and scanned for their NIRS spectral profiles. Selected samples will be selected for laboratory analyses by ARS-Lincoln; comprehensive compositional analyses by Bruce Dien (CenUSA Collaborator/ARS-Peoria) and pyrolysis by Akwasi Boateng (CenUSA Collaborator/ARS-Wyndmoor) will be initiated.

- Clonal pieces of switchgrass plants will be moved from the field to the greenhouse for intermating during the winter months (Ken Vogel).

- Seed harvested during the autumn of 2012 will be cleaned and tested. Seed of one experimental stain will be made available for seed producers pending official cultivar release (Ken Vogel and Mike Casler).

- Plant Canada milkvetch seedlings in the greenhouse for four breeding populations for potential use in different Midwest Plant Adaptation Regions. Plant seedlings for Partridge Pea selection nurseries (Ken Vogel).

- Insect sampling plans will be developed for the summer of 2013 (Tiffany Heng-Moss, CenUSA Collaborator/UNL, Ken Vogel, Rob Mitchell, CenUSA Co-Pd/ARS Lincoln, Ken Vogel, and Mike Casler). We will continue identification of insects collected in 2012.

- Complete statistical analyses of 2012 virus ratings of switchgrass genotypes (Gary Yuen, Collaborator/UNL and Ken Vogel).

- Continue to screen selected switchgrass, big bluestem, and indiangrass cultivars and experimental strains for their susceptibility to greenbugs and sugarcane aphids (Tiffany Heng-Moss, UNL).

- **Compositional analyses**. Complete training of technician in plant cell wall compositional analysis and initiate full laboratory composition analyses capacity (Bruce Dien).

- Continue py-GC/MS and TGA experiments and associated statistical analysis on 2012 sample sets of switchgrass. Prepare for initial analyses of big bluestem, and indiangrass samples.

- Initial draft of manuscript on effect of genetic differences in biomass composition of 12 divergent switchgrass genotypes on pyrolysis products completed for review.

3. **Actual Accomplishments (Planned Activities)**

- **Breeding & Genetics – Lincoln, Nebraska (Ken Vogel)**

  ✓ In 2012, over 8000 biomass samples were collected for analyses. All drying and weighting work has been completed and over half of the samples have been ground. Grinding work is expected to be completed in March 2013. NIRS scanning work for the Lincoln samples is in progress. A CenUSA funded laboratory research technologist position was re-filled at Lincoln and should enable the NIRS work to be completed. A set of lowland switchgrass samples which differ significantly in lignin and total ash concentration were selected from a switchgrass genetic study for compositional analysis and micro-pyrolysis analyses. The study is designed to determine the effect of genetic and compositional differences on pyrolysis yields from lowland biomass type switchgrass. The samples have been sub-divided and a set of subsamples were sent to Bruce Dien and Akwasi Boateng in early March for analysis of composition and pyrolysis products, respectively. One set will be used at Lincoln for fiber, total C, N, and calorie analysis. Another set of samples based on harvest procedures and methods is being developed.

  ✓ Clonal pieces or ramets of switchgrass plants selected from three different source populations, both upland and lowland, were moved into the greenhouse, flowering induced via lighting control to synchronize flowering periods, and paired plant crossing was initiated at Lincoln. Previously, paper pollination bags developed for use on sorghum were used in making controlled crosses with switchgrass with variable success. The paper pollination bags are often too small for the switchgrass panicles and the panicles have to be trimmed. For these crosses, fabric pollination bags were made using a polyester fabric than has a 41-micron mesh opening. Switchgrass pollen ranges in size from 45 to over 50 microns in diameter. The fabric pollination bags that were made are 60 cm in length and 15 cm in diameter. They keep pollen inside the bag but allow air movement through the bag.

  ✓ All seed harvested in 2012 from field polycross nurseries and seed increase fields has been cleaned as scheduled and seed quality tests have been initiated. Seed production in non-irrigated isolations in Nebraska was adversely affected by the drought in 2012.

  ✓ Canada milkvetch seed increase nurseries were grown under irrigation in 2012. Seed was harvested from all nurseries and seed cleaning has been completed. Sufficient seed was obtained from the hardiness zone populations to support germplasm release and research needs. The seed production objective was met without needing to establish additional transplanted nurseries of Canada milkvetch as originally planned. Seed was also harvested from plants in three different maturity groups in a genetically broad based Partridge Pea selection nursery and has been cleaned. The seed will be used to establish additional selection nurseries in 2013. These selection nurseries will be established using greenhouse-grown seedlings.

- **Breeding & Genetics - Madison, Wisconsin (Mike Casler)**

  See the summary on "Breeding for Biomass Yield in Switchgrass" in the Significant Accomplishment Summary section above.

  ✓ **Progress in developing DNA markers for genomic selection in switchgrass**. Development of the exome capture pipeline for detecting and evaluating DNA markers of switchgrass breeding populations was completed. Simulation studies of various levels of multiplexing genotypes within a single lane of an Illumina Sequencer revealed that the loss of information with 12-plex or 24-plex coverage falls within acceptable limits. Multiplexing at the 12-plex level led to an average genome coverage of 110Mb (6% of the entire genome), including approximately 1.3 million SNP (single-nucleotide polymorphism) markers read at a depth of two or more reads and 1 million SNP markers read at a depth of five or more. The results of these simulations indicate that between 12 and 24 different genotypes can be sequenced in a single lane without compromising the integrity of the genomic selection protocol.

- **Entomology - Univ. Nebraska - Lincoln (Tiffany Heng-Moss)**

  ✓ During the 2012 growing season, both pitfall traps and yellow sticky insect traps were used in CenUSA breeding, management, and seed production nurseries in Eastern Nebraska. Arthropods collected in the pitfall traps have been sorted and identified and identification and characterization of the arthropods collected on the sticky traps will be completed by the end of March 2013. Data will be summarized to identify potential pests and beneficial arthropods and characterize their seasonal abundance.

  ✓ Greenhouse screenings were continued in which selected switchgrass, big bluestem, and indiangrass cultivars and experimental strains were evaluated for their susceptibility to greenbugs and sugarcane aphids. To date, 'Kanlow' switchgrass exhibits the highest level of resistance to the both aphids.

- **Plant Pathology – Univ. Nebraska - Lincoln (Gary Yuen)**

  ✓ **Initiate work on identifying virus species causing severe symptoms on some plants in the field and begin conducting statistical analyses of disease severity data.** Leaf samples collected in July 2012 from four breeding nurseries and a large genetic field study were tested via commercial immunoassay kits for the presence of six known viral pathogens of switchgrass: panicum mosaic virus (PMV), sugarcane mosaic virus (SMV), wheat streak mosaic virus (WSMV), and barley yellow dwarf virus (BYDV) serotypes rpv, pav and mav. PMV was the most prevalent virus, detected in 87% of 120 samples from plants exhibiting severe virus symptoms. The incidence of other viruses in the same set of samples was much lower: BYD-rpv, 7%; SCM, 6%; BYD-pav, 2%; BYD-mav, 1%; and WSM, 0%. Preliminary analysis of virus severity data from the four breeding nurseries revealed incidences of virus infection ranging from 48 to 59 percent of the plants, with the incidences of plants with severe virus symptoms (mottling in all of the foliage and stunting) ranging from 8 to 24 percent.

- ✓ **Initiate testing of fungal and bacteria stains isolated from diseased leaves for pathogenicity on switchgrass.** Preliminary testing of bacterial isolates revealed several isolates able to cause mild necrosis upon artificial inoculation of switchgrass seedlings. These isolates will be identified following confirmation of pathogenicity. Fungi isolated from diseased leaves were identified as belonging to several genera previously reported in switchgrass (e.g. *Alternaria, Bipolaris, Fusarium* and *Phoma).*
- ✓ **Initiate work on isolating fungi from diseased crown and root tissue of switchgrass.** Fungi isolated from switchgrass crowns and roots include *Fusarium* and *Pythium*, which are known to be common root-infecting organisms. Methods for testing isolated fungi for infection of switchgrass roots are being developed.

- **Compositional Analyses – ARS-Peoria, (Bruce Dien).**

A technician has been hired and has been trained to carryout analysis. An HPLC-PAD has been setup using a newly released column by Dionex developed for biomass analysis. The HPLC-PAD has been validated for measuring sugar concentrations (Figure 1. Calibration curve for various measured sugars as detected by HPLC-PAD).

The column gives baseline speparation of sugars present in the standard (Figure 2A. Figure 2A. Chromatogram of standard sugars acquired on the Dionex system) and acid-digested biomass samples (Figure 2B. Chromatogram of switchgrass cell wall carbohydrate sample acquired on Dionex system). A calibration biomass sample set has been collected that includes switchgrass (5 samples), Reed Canary Grass (1 sample, used as representative of cool season grasses), indiangrass (1), and Bluestem Grass (1). They are currently being analyzed for soluble sugars, fructans, starch, structural carbohydrates, Klason lignin, and total ash. Fructans were not detected in significant amounts in switchgrass, indiangrass, and big bluestem and therefore will not need to be measured for these samples. For measurement of some of the other components, the relative standard deviations were above 15% and the protocols are currently being modified to improve accuracy. See figures below.

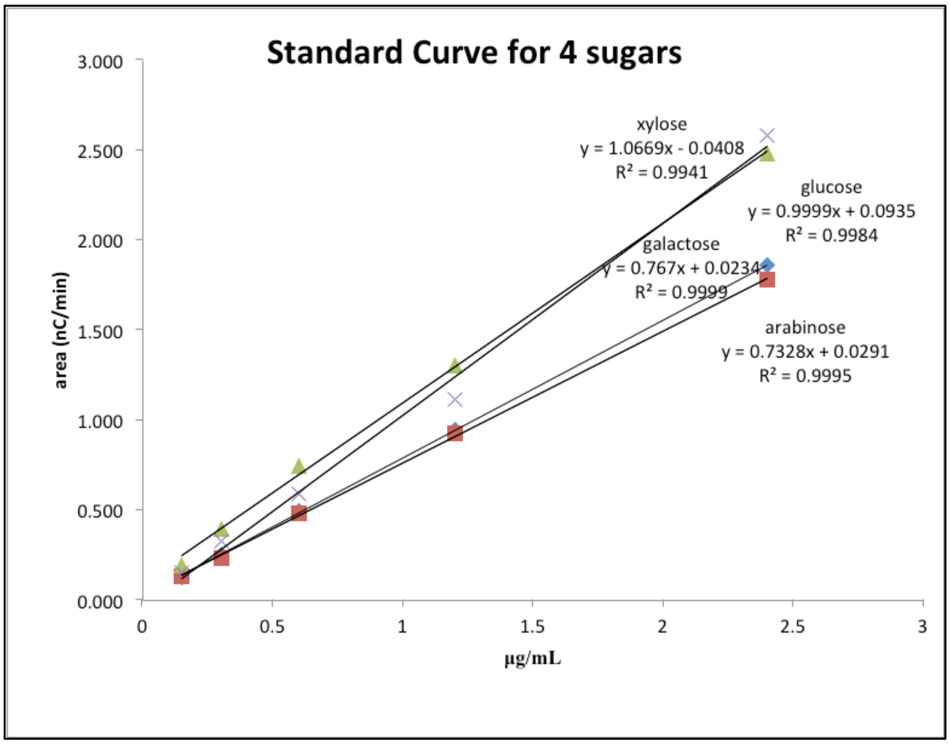

Figure 1. Calibration Curve for Various Measured Sugars as Detected by HPLC-PAD

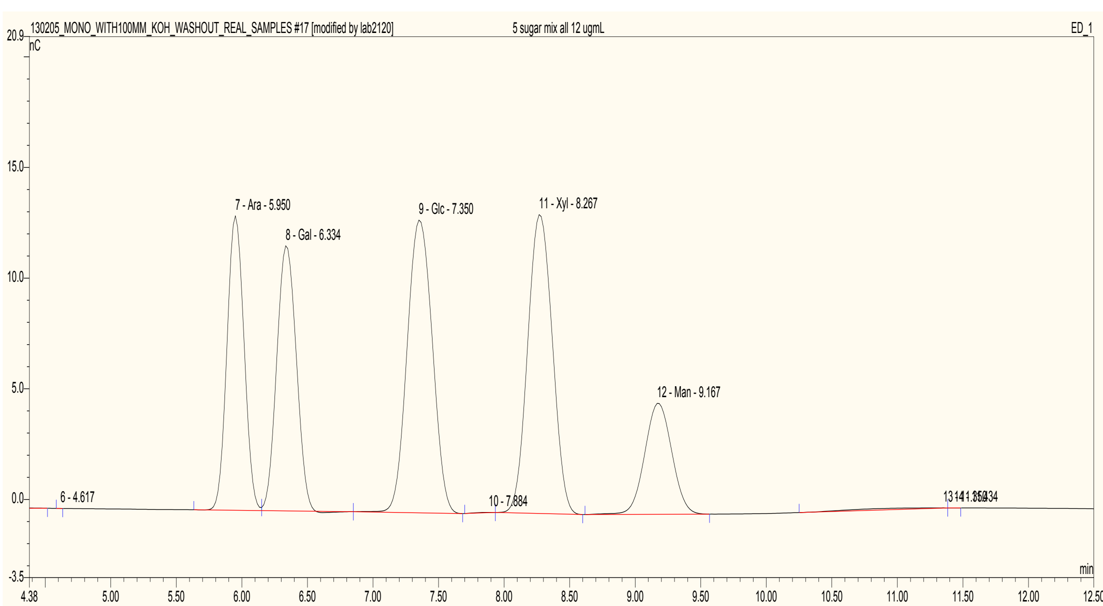

Figure 2A. Chromatogram of standard sugars acquired on the Dionex system

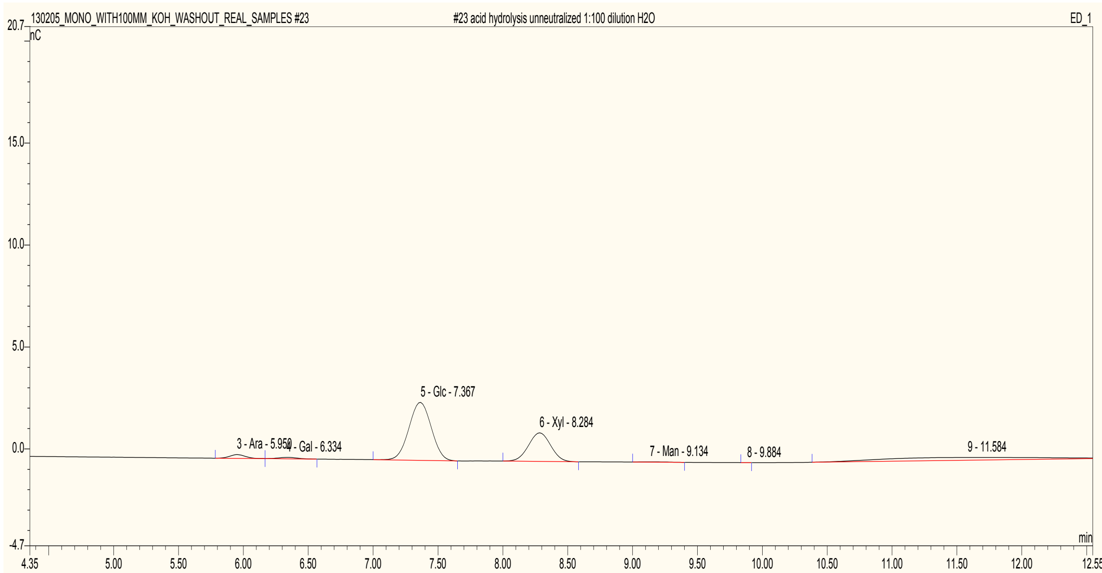

Figure 2B. Chromatogram of Switchgrass Cell Wall Carbohydrate Sample Acquired on Dionex System

- **Pyrolysis – ARS- Wyndmoor, Pennsylvania (Akwasi Boateng)**

  ✓ Manuscript in final stages of preparation on pyrolysis of biomass from stem tissue of 12 upland switchgrass genotypes developed by divergently breeding for differences in in vitro dry matter digestibility and with well-characterized differences in lignin concentration, biomass quality traits, and stem anatomy. The study was conducted to determine the effects of biomass composition on yields of products obtained in a pyrolyser. Yields for several groups of compounds were influenced by the presence or absence of a catalyst. In particular, acids were more prevalent in the absence of the catalyst, while aromatics were significantly enriched in the presence of the catalyst. Significant differences in the recovery of a number of phenolic compounds were attributable to the changes in cell wall composition and plant architecture in the plants analyzed. These differences in turn were the result of divergently breeding plants for ruminant digestibility. Overall, the results indicate that switchgrass germplasm can be bred for improved conversion in thermochemical platforms. Data will be presented at the SIMM meeting in late April 2013.

  ✓ Additional pyrolysis and associated gas chromatography/mass spectrometry work was temporarily delayed until a set of biomass type lowland switchgrass samples were selected that could be used to test the effects of genetic differences in lignin and biomass ash content on pyrolysis product yields.

4. **Explanation of Variance**

Overall accomplishments exceeded goals. In the compositional analyses work, the soluble sugar analysis will need to be modified to be compatible with HPLC analysis. Pyrolysis work was temporarily delayed while a sample set was developed to test for the effects of genetic differences in both lignin and ash concentration of biomass from lowland, biomass type switchgrass on pyrolysis yields.

5. Plans for Next Quarter

- **Breeding & Genetics – ARS-Lincoln, NEBRASKA (Ken Vogel)**
  - ✓ Complete greenhouse crosses, clean and process seed from crosses.
  - ✓ Complete grinding of 2012 biomass samples. Complete 75% of NIRS scans. Complete NIRS prediction of samples from selection nurseries scheduled for completion in 2013.
  - ✓ Summarize first biomass mineral analysis study comparing methods and laboratories.
  - ✓ Complete early spring work on field nurseries.
  - ✓ Complete planned purchase of new NIRS unit and have laboratory technicians trained in its use.
- **Breeding and Genetics – ARS-Madison (Mike Casler)**
  - ✓ Complete establishment of 40K seedlings of switchgrass and big bluestem in greenhouse.
  - ✓ Submit switchgrass manuscript on 20 years of breeding for increased biomass yield.
  - ✓ Submit first set of parental genotypes to *Joint Genome Institute* for sequencing. Conduct fertilization, weed control, and soil sampling on all field studies in Wisconsin.
- **Compositional Analyses – ARS-Peoria (Bruce Dien)**
  - ✓ Finalize protocol for compositional analysis of neutral and acidic carbohydrates and Klason lignin and validate with calibration set.
  - ✓ Initiate analyses of lowland switchgrass sample set (CenUSA Set 1) differing in lignin and ash.
- **Pyrolysis – ARS- Wyndmoor (Akwasi Boateng)**

- ✓ Complete and submit for publication a manuscript on pyrolysis products from upland switchgrass genotypes differing in stem lignin concentration.
- ✓ Initiate py-GC/MS analyses of lowland switchgrass sample set (CenUSA Set 1) differing in lignin and ash concentration.

- **Entomology – University of Nebraska-Lincoln (Tiffany Heng-Moss)**
  - ✓ Collaborate with Drs. Vogel, Mitchell and Casler to develop insect sampling plans for year 2.
  - ✓ Begin sampling nurseries for insects and other arthropods in late May.
- **Plant Pathology – University of Nebraska-Lincoln (Gary Yuen)**
  - ✓ Determine presence of satellite PMV (SPMV) in samples from PMV-infected switchgrass plants.
  - ✓ SPMV is a separate virus species that can infect plants only in conjunction with PMV. Research with other plant species indicated that co-infection of the two viruses results in severe stunting.
  - ✓ Coordinate with other project personnel for a survey of multistate field experiments for diseases.
  - ✓ Analyze virus severity data collected from breeding nurseries to identify genotypes exhibiting lowest and highest levels of virus symptoms.
  - ✓ Continue efforts in pathogenicity testing of organisms isolated from switchgrass (i.e. organisms referenced above.

6. Publications, Presentations, and Proposals Submitted

- Bruce S. Dien, Patricia J. O'Bryan, , Michael D. Casler, Michael A. Cotta, Hans-Joachim G. Jung, JoAnn F.S. Lamb, Robert B. Mitchell, Gautum Sarath and Kenneth P. Vogel. "Variation in composition and yields among populations of alfalfa stems, reed canarygrass, and switchgrass for biochemical conversion to sugars and ethanol," 245th ACS National Meeting & Exposition, New Orleans, LA, April 7-11, 2013, [Accepted for oral presentation.]
- Gautam Sarath, Mark Hammer, Aaron Saathoff, Mullen, C., Akwasi Boateng, Robert B. Mitchell, Kenneth P. Vogel, and Scott Sattler. 2013. "Switchgrass, cell walls and pyrolysis 35th Symposium on Biotechnology for Fuels and Chemicals," Portland, OR. April 29-May2, 2013. (Abstract, oral presentation).

Objective 2. Sustainable Feedstock Production Systems

The Sustainable Feedstock Production Systems objective focuses on conducting comparative analyses of the productivity potential and the environmental impacts of the most promising perennial grass bioenergy crops and management systems using a network of 14 fields strategically located across the Central United States. The overarching goal is to produce a quantitative assessment of the net energy balance of candidate systems and to optimize perennial feedstock production and ecosystem services on marginally productive cropland while maintaining food production on prime land.

1. Planned Activities

- Much of the research planned for this quarter dealt with sample processing and planning for the next quarter. Nearly all planned research for this first quarter was completed on schedule.

2. Actual Accomplishments

- **Iowa State University**

  ✓ **Armstrong System Plots**. Analysis of soil samples from the 128 1.2-m time zero soil cores from the system plots on the Armstrong Farm is making good progress. Analysis of approximately 30% of the total of 768 samples is complete. We anticipate completing these analyses by August 2013. Soil analyses include total C, total N, POM-C, EC, CEC, pH, aggregate stability, and bulk density. Analysis of fall 2013 surface soil samples for Mehlich 3 extractable nutrients and pH is completed.

  ✓ Due to 2012 drought there was a poor stand establishment on bioenergy switchgrass plots planted with a nurse crop on the Armstrong System plots. The switchgrass plots will need to be replanted in 2013. We are waiting to hear from Rob Mitchell on the availability of seed. We are planning not to use a nurse crop in 2013 to avoid similar problems which might occur if the drought continues. Stand establishment on the LIHD and HILD plots in 2012 was also poor due to drought; however, these plots are anticipated to recover in 2013 assuming adequate moisture.

  ✓ **Boyd Biochar Factor Plots**. Preliminary analysis of the 2012-grain and biomass yields from the biochar factor plots on the Boyd Farm is complete. Data for surface soil moisture content was measured 13 times during June and July of 2012 and infiltration measured on each of the Boyd plots has also been analyzed. Analysis of the fall 2013 soil samples for Mehlich 3, CEC and pH are complete. Total C and N have yet to be analyzed. Rivka Fidel, Ph.D. student, is gearing up to measure CO_2 and N_2O emissions on the Boyd biochar factor plots during the 2013 growing season.

- ✓ **Field 70/71 plots**. Biochar was successfully applied after the fall of 2012 after harvest. Soil samples were collected after harvest, but before the biochar application. Analysis of these samples is ongoing. Preliminary analysis of grain and biomass yields for 2012 is complete. Bioenergy alfalfa will be seeded on some of the plots in 2013.

- ✓ Catherine Bonin, a new post doc, has joined Emily Heaton's group and will be leading the plant research at the Systems site.

- **University of Illinois**

  - ✓ Preparing 2013-plot location for planting. Since the site was on fallow marginal land, weed pressure is expected to be heavy. The site was tilled in the fall and sprayed to control weeds.

  - ✓ Planning to collect spring stand count data on the 2012 plots to determine establishment success.

  - ✓ The comparison field trial of switchgrass, big bluestem, prairie cordgrass, and Miscanthus x giganteus was harvested on November 15, 2012. Harvested biomass was weighed in the field. Samples were collected and dry biomass of the sample was determined.

- **University of Minnesota - Factor analysis plots, Becker, MN**.

  - ✓ On October 30, 2012 we harvested the factor analysis plot at Becker, Minnesota. 12' x 3' swaths were cut using the Carter harvester and weighed in the field. We hand-harvested two 1/4-m subsamples from each feedstock plot (n =144 subsamples).

  - ✓ Weed pressure was high. We visually estimated grass content in each subsample, but could not easily separate grass from weeds. Samples were weighed, ground and sent to Nebraska for analysis.

  - ✓ The low diversity mix will likely need to be reseeded. We will estimate how much stock we have remaining and may need to request more seed if it is available. We believe the Bioenergy, 'Shawnee', 'Sunburst' and the polyculture (CRP mix) are well established.

  - ✓ Plans are in place for seeding an additional factor plot at Lamberton in 2013.

- **USDA-ARS, Lincoln**

  - ✓ Received 2012 samples from MN.

- ✓ We are working with Outreach and Extension Objective collaborator Sue Hawkins to complete and review extension material.
- ✓ We are working with Outreach and Extension Objective collaborator Pam Porter and Jeff Volenec to complete a fact sheet on establishing bioenergy demonstration sites.
- ✓ **Site Visits**. We made a site visit to Illinois to evaluate plots. We would like to visit all System, Factor, and Demo sites this spring.
  - o Evaluate Iowa system plots in March 2013. We have discussed Iowa demonstration sites, but nothing has yet been scheduled.
- ✓ **Summer 2013 Establishment Field Day**. We have tentatively scheduled an establishment field day with Kevin Shinners for this summer to showcase herbaceous perennial feedstock establishment.
- ✓ Completed frequency grids for distribution to the demonstration site coordinators.
- ✓ We are planning now for burning the 2012 demonstration sites in April 2013, and seeding the 2013 demonstration sites in April.
- ✓ Bioenergy switchgrass seed cleaning has been completed and testing is beginning. Seed is in short supply. Much of the seed will be needed for release this spring.
- ✓ Continuing to sample the Nebraska Systems Analysis plots at 30-d intervals (as conditions allow) to determine DM losses over winter.
- ✓ Post-frost establishment year biomass from the Systems Analysis plots averaged 3.4 tons/acre for switchgrass, 1.2 tons/acre for big bluestem, and 1.9 tons/acre for the low diversity mixtures. Average rainfed maize grain yield on the control plots was 102 bu/acre and we removed 1.4 tons/acre of corn stover.
- ✓ We are working with CenUSA collaborator Virginia Jin to prepare for GHG sampling in the Nebraska Systems Analysis plots throughout the 2013 growing season.
- ✓ Dr. Virginia Jin completed the analysis of the baseline soil samples from the Nebraska Systems Analysis plots (Figure 3. Baseline Soil Data – CenUSA System Analysis Plots located near Mead, NE). Soils were sampled on June 14, 2012 with a hydraulic soil corer from sampling locations selected based on soil electrical conductivity values determined by a soil EC survey conducted on April 4, 2012. Soil pH and EC measured for 1:10 soil: water ratio. Soil-test N based on 2M KCl extractions (1:10). Soil-test P based on Mehlich-3 extractions (1:10). Values shown are the average values of 12 cores per depth per plot (n=6 per A and B subplots

within each large plot). Values are for soil concentrations only (per unit air-dried soil), though nutrients per unit area will likely show same trends because soil bulk densities did not vary significantly.

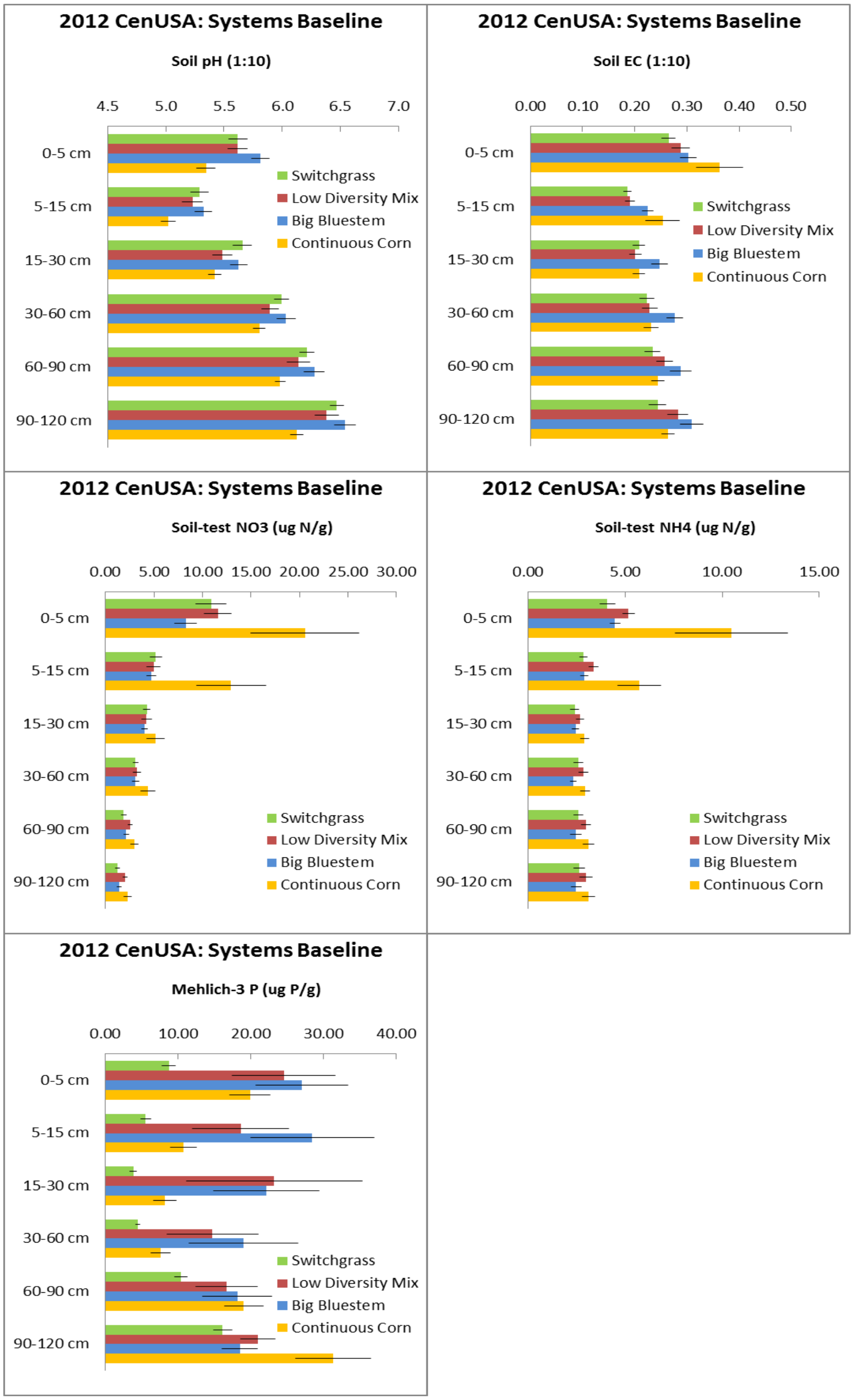

Figure 3. Baseline Soil Data – CenUSA System Analysis Plots located near Mead, NE

- ✓ Submitted lowland and upland switchgrass samples to CenUSA Advisory Board chair and ADM President for Research Tom Binder to evaluate their feedstock fractionation process. Fractions were returned to ARS-Lincoln for further analysis.

- ✓ Worked with CenUSA collaborators Deana Namuth-Covert and Amy Kohmetscher with assistance from Three Pillars Media to complete the CenUSA video, "Switchgrass Planting Practices for Stand Establishment" at the CenUSA Vimeo Channel (https://vimeo.com/61137878) and the CenUSA YouTube Channel (http://youtu.be/vwBQ3aYpfmM).

- **Purdue University**

  - ✓ All plant tissues from the factor-analysis plots at *Northeast Purdue Agricultural Center*, *Southeast Purdue Agricultural Center* and *Throckmorton Purdue Agricultural Center* and the systems analysis plots at the *Water Quality Field Station* have been dried and ground, and are ready for analysis.

  - ✓ Analysis has started on the following biomass attributes: total C and N; total ash; P and K; fiber, and non-structural carbohydrates.

  - ✓ Soil samples are dried and we are waiting for the arrival of a new soil grinder to expedite soil processing prior to analysis.

  - ✓ Greenhouse gas emission data from the *Systems Plots at the Water Quality Field Station* are becoming available. Note these data are preliminary and are not for publication/distribution beyond this report. Season-long means reveal that, while perennial biomass production systems may produce slightly more CO_2, they produce very little CH_4 and NO_2. Conventional grain cropping systems in the Midwest US serve as controls for these side-by-side comparisons. On average, these corn production systems emit nearly 50-times more NO_2 than the perennial biomass systems. Reminder: extremely dry weather occurred in summer 2012.

  - ✓ Biomass yield data is being summarized and analyzed statistically. Below are representative yield data from these analyses:

    - Biomass yield (kg dry matter/ha) of switchgrass (Shawnee) in 2012 as influenced by current nitrogen fertilizer rate and previous, long-term application of P and K fertilizer. Nitrogen had a modest impact on biomass yield. Potassium main effects were significant with a reduction in biomass observed with previous K application (8224 vs. 7865 kg/ha at 0 and 400 kg K/ha/yr, respectively). The main effect of previous P application was not significant. Reminder, extreme drought occurred at this location in Summer 2012.

Table 7. Previous K & P, kg/ha/yr				
	0 kg N/ha/yr	50 kg N/ha/yr	100 kg N/ha/yr	150 kg N/ha/yr
0 K/0 P	7932	8173	8846	8285
0 K/75 P	7628	7864	8818	8249
400 K/0 P	8084	7641	7520	7642
400 K/75 P	8054	8049	8018	7911
Mean	7924	7932	8300	8022

- Biomass yield (kg dry matter/ha) of *Miscanthus x g* in 2012 as influenced by nitrogen (N), phosphorus (P), and potassium (K) fertilizer rates. Nitrogen had a modest impact on biomass yield. The main effect of previous P application was not significant. Reminder, extreme drought occurred at this location in the summer of 2012.

Table 8. K & P, kg/ha/yr				
	0 kg N/ha/yr	50 kg N/ha/yr	100 kg N/ha/yr	150 kg N/ha/yr
0 K/0 P	15321	12843	12888	13310
400 K/75 P	15787	12307	14362	13174

- Biomass yield (kg dry matter/ha) of switchgrass (Shawnee) in 2012 as influenced by site quality in the context of phosphorus (P), and potassium (K) fertility. Maize and alfalfa yields were significantly reduced on the very low and low sites, and were high on the medium high and high sites. Switchgrass yields were unaffected by site quality defined in this manner in 2012. Reminder, extreme drought occurred at this location in summer 2012.

- For modeling biomass productivity in a landscape context, we have mapped all the marginal land areas in Indiana. We are setting up an APEX model to evaluate impacts of switchgrass and *Miscanthus* production of those marginal lands on hydrology (runoff volume, percolation), water quality (losses of sediment, N, and P) and biomass production. We have also set up a SWAT model in the Wabash River Watershed and White River Watershed to evaluate impacts of energy crop production on river water quality and quality. The model has been calibrated for stream flow. We are currently calibrating the model for measured sediment, N, and P concentrations and loads.

Table 9. Site productivity based on previous alfalfa and maize performance			
	Number of sites/plots	Biomass yield, kg/ha	Standard error of biomass yield, kg/ha
Very Low	3	8618	114
Low	20	8508	144
Medium Low	11	8298	304
Medium	17	8261	225
Medium High	18	8441	197
High	11	8600	183

3. Explanation of Variance

- All planned research is being conducted on schedule. Drought conditions prevented the harvest of some plots established in 2012 and some winter sampling was delayed by winter weather.

4. Plans for Next Quarter

- Due to drought, some stands planted in 2012 will be evaluated for re-planting.
- Plot residue will be removed by burning or mowing plots planted in 2012.
- New Factor and Demonstration plots will be planted at some locations as described in the original project plan.
- Otherwise, the activities for the upcoming quarter will proceed as originally described in the proposal.

5. Publications, Presentations, and Proposals Submitted

- Made two presentations to the *Missouri Certified Crop Advisors Workshop* (January 22, 2013), one presentation to the *North Central Weed Science Society*, two presentations to the *2012 Iowa Crop Management Conference*, one presentation to the *Heartland Regional Water Workshop*, and one presentation to the *Sun Grant Regional Feedstock Partnership* (February 15, 2013).

Objective 3. Feedstock Logistics

The Feedstock Logistics objective focuses on developing systems and strategies to enable sustainable and economic harvests, transportation and storage of feedstocks that meet agribusiness needs. The team also investigates novel harvest and transport systems and evaluates harvest and supply chain costs as well as technologies for efficient deconstruction and drying of feedstocks.

1. Planned Activities – University of Wisconsin

Planned research activities included:

- Analysis of data collected in 2012;
- Management of the bale storage study;
- Development of machine configurations to combine cutting/intensive conditioning/tedding;
- Collection of post-storage size-reduction energy requirements of bales.

2. Actual Accomplishments – University of Wisconsin

We are statistically analyzing data from our work on bale aggregation, grass drying rate, and grass size-reduction. The analyzed data will serve as the basis for three papers that will be presented at the ASABE International Meeting in July 2013. Preparation of these manuscripts started during this period.

Bales were placed into storage in the fall of 2012 to investigate means to reduce DM losses from dry bales stored outdoors. Four treatments were considered in this dry bale study, including indoor and outdoor storage and bales wrapped in plastic film (either individually or in a tube). The bales have been monitored during the winter months to insure the study is progressing as planned. Bales will be removed from storage in early summer.

In 2012, we determined both intensive conditioning and wide-swath drying enhanced the drying rate of switchgrass. We have begun development of a machine configuration to combine cutting/intensive conditioning/tedding into a single operation. This system will involve a mower front-mounted on a tractor which will also pull a towed intensive conditioner equipped with a mounted tedder. We have arranged for loan of a tractor and mower to accomplish the first operations and are working to acquire the intensive conditioner and tedder. The system will be completed during the winter months and initial functional tests will be conducted using alfalfa and grasses in the summer before harvesting our perennial grasses in the fall.

We continue to quantify the energy required to size-reduce perennial grasses post-storage. Our work during the winter months have focused on improvements to our system of data collection, specifically the manner in which we determine the mass of material processed during the time power and fuel use are quantified. Once our process is improved, we will collect data on the energy required to tub grind bales at various conditions. Specifically we will tub grind frozen bales and bales removed from storage during the spring thaw when they are damp.

Finally, we have rented 32 acres of marginal land in which we will establish a variety of perennial grasses. Ken Vogel, Rob Mitchell and Mike Casler are providing input on the type and variety of grasses we will establish in the spring. A grass establishment outreach field day is under consideration.

3. Explanation of Variance – University of Wisconsin

There were no variances – we accomplished all that we had planned during this period.

4. Plans for Next Quarter – University of Wisconsin

We plan to:

- Finish analyzing 2012 data and prepare manuscripts for the American Society of Agricultural and Biological Engineers meeting;
- Manage our bale storage study;
- Finish configuration of the combined cutting/intensive conditioning/tedding machine;
- Collect post-storage size-reduction energy requirements of bales removed from storage during and after outdoor winter storage;
- Harvest grasses that were over-wintered;
- Begin establishment of perennial grasses on rented acreage and potentially develop an outreach field day.

5. Publications, Presentations, and Proposals Submitted – University of Wisconsin

None to report this period.

Objective 4. System Performance Metrics, Data Collection, Modeling, Analysis and Tools

This objective provides detailed analyses of feedstock production options and an accompanying set of spatial models to enhance the ability of policymakers, farmers, and the bioenergy industry to make informed decisions about which bioenergy feedstocks to grow, where to produce them, what environmental impacts they will have, and how biomass production systems are likely to respond to and contribute to climate change or other environmental shifts.

We focus on four overarching tasks:

- **Task 1**. Adapt existing biophysical models to best represent data generated from field trials and other data sources;
- **Task 2**. Adapt existing economic land-use models to best represent cropping system production costs and returns;
- **Task 3**. Integrate physical and economic models to create spatially explicit simulation models representing a wide variety of biomass production options;
- **Task 4**. Evaluate the life cycle environmental consequences of various bioenergy landscapes.

1. Planned Activities

Iowa State University

The first two broad tasks under Objective 4 are to adapt existing biophysical models to best represent field trials and other data and to adapt existing economic land-use models to best represent cropping system production costs and returns.

University of Minnesota

Planned activities for this quarter include continued work on Task 1 and Task 2 and the initiation of Task 3.

2. Actual Accomplishments

Iowa State University

- We have received a new version of the EPIC model that features an entirely new soil carbon cycling submodel (along with the GHG emission algorithms). The decision to replace the existing soil carbon submodel, which was based on the methods used in the Century/DAYCENT models, was made by Dr. César Izaurralde (www.globalchange.umd.edu/staff/rizaurralde/) and colleagues to deal with persistent stability problems (which we noted in previous quarterly reports). We have noticed improved soil carbon results in initial testing of this code.
- We completed the draft of a policy brief that provides an assessment of the potential for cellulosic feedstocks to reduce the frequency and magnitude of flood events in the Raccoon River Watershed in Iowa. We use a watershed based hydrologic model to represent changes in water movement under different land uses in the watershed. First, we develop a baseline scenario of flood risk based on the current land use and typical weather patterns. We then simulate the effects of varying levels of increased perennials

on the landscape under the same weather patterns and compare the change in stream flows and water quality to the baseline scenario. A manuscript based on this paper is now completed, revisions have been invited and we are nearly ready for resubmission.

- We have begun work on a manuscript entitled "Optimal Placement of Second Generation Biofuels in a Watershed: Is Marginal Land the Answer?" for presentation at the annual meeting of the *Agricultural and Applied Economics Association*. This paper will address concern about competition between corn used for ethanol production and corn used for feed has led to the suggestion that second generation feed stocks, such as switchgrass and other perennial grasses, be restricted to low productivity "marginal" land to avoid food price effects of biofuel production. Although perennial grasses have promising environmental attributes related to GHG emissions, soil erosion, and water quality, the technology to cost effectively convert them to liquid fuels is still under development. Further, these feedstocks are bulky and there are likely to be large agglomeration economies by locating fields near each other. From an environmental perspective, the optimal location of switchgrass will likely depend on the typography of fields in a watershed, proximity to waterways and soil characteristics. We present a simple model of agricultural land use to study the efficiency tradeoffs associated with restricting switchgrass to marginal land vs. allowing it to be located where it would be most profitable or achieve the greatest water quality benefits. We consider these tradeoffs explicitly for the Raccoon River watershed.

- A major component of the ISU-CARD modeling work in this objective involves the improvement of SWAT models for the Upper Mississippi River Basin and the Ohio Tennessee River Basin with USGS 12-digit subwatersheds. There is now a much denser subwatershed delineation; e.g., 5,279 12-digit subwatersheds versus 131 8-digit subwatersheds for the UMRB. This modeling structure will provide the ability to perform enhanced scenarios including greatly refined targeting scenarios to study placement of switchgrass and other biofuel crops in the landscape to evaluate the water quality and carbon effects at the landscape level. Initial calibrations of the model are complete. We have moved into a phase of in-depth testing of the Upper Mississippi River Basin (UMRB) and Ohio-Tennessee River Basin (OTRB) SWAT models. At present, the focus is on using automatic calibration via the SWAT-CUP software (www.eawag.ch/forschung/siam/software/swat/index) using simpler model structures that are delineated with the 12-digit subwatersheds but with no HRUs (see http://pubs.usgs.gov/tm/tm11a3/ for descriptions of 12-digit and other standard watershed classifications).

University of Minnesota

Our major accomplishment this quarter was finishing compilation of our switchgrass datasets and corn trial yields in our investigation of yield gaps. We began our initial analysis, which is revealing potentially large areas of improvement when commercializing production.

We received comments back from a journal on our comparison of U.S. federal agency bioenergy feedstock production scenarios for achieving Renewable Fuel Standard (RFS2) biofuel volumes. We have been working on a revision and will be resubmitting it in the current quarter.

Other ongoing projects include continued work on compiling production cost and return data for switchgrass, exploring different biodiversity models for use in our InVEST modeling, and writing of scripts to automate the modeling of biomass production placement on the landscape.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

Iowa State University

Continue work on the first two tasks:

- To adapt existing biophysical models to best represent field trials and other data, and
- To adapt existing economic land-use models to best represent cropping system production costs and returns.

We hope to have a draft of a paper studying the optimal placement of switchgrass with respect to both bioenergy and water quality goals completed by the summer of 2013.

University of Minnesota

Next quarter will include continued work on Tasks 1, 2, and 3, as well as continued work ahead of schedule on Task 4 (Evaluate the life cycle environmental consequences of various bioenergy landscapes).

5. Publications, Presentations, and Proposals Submitted

- Gonzalez-Ramirez, J., A.Valcu, and C. Kling. “An Overview of Carbon Offsets from Agriculture,” Annual Review of Resource Economics 4 (2012): 145-160.

- Jason Hill. "Biofuels: Life cycle impacts on land and air" Workshop on the Nexus of Biofuels Energy, Climate Change, and Health. Institute of Medicine of the National Academies, Washington, DC, January 2013.

- Jason Hill. "Evaluating life cycle impacts of biomass production for bioproducts and bioenergy" Catalysis Center for Energy Innovation, Minneapolis, MN, January 2013.

- Jason Hill. "Green engineering – The future" The Society of Women Engineers Region H Conference, Minneapolis, MN, February 2013.

- Kling, C. National Science Foundation, "Climate and Human Dynamics as Amplifiers of Natural Change: A Framework for Vulnerability Assessment and Mitigation Planning, (Principal Investigator), 2012-2016, $480,000.

- Markets and Regulation: Alternative or Complements, presentation to the 2012 Agricultural Outlook Forum, sponsored by USDA, Washington DC, February 2012, available on www.card.iastate.edu/environment/presentations.aspx.

- Rabotyagov, Sergey, Adriana Valcu, and Catherine L. Kling. "Reversing the Property Rights: Practice-Based Approaches for Controlling Agricultural Nonpoint-Source Water Pollution When Emissions Aggregate Nonlinearly" Presented at Global Environmental Challenges: The Role of China, Shanghai, China December 12-13, 2012.

- The Potential for Agricultural Land Use Changes in the Raccoon River Basin to Reduce Flood Risk: A Policy Brief for the Iowa Flood Center, presentation, available at www.card.iastate.edu/environment/presentations.aspx.

- "Water Quality: Corn vs. Switchgrass," Presented at the Roundtable on Environmental Health Sciences, Research, and Medicine "The Nexus of Biofuels Energy, Climate Change, and Health" Institute of Medicine, National Academy of Sciences, January 2013.

Post-Harvest

Objective 5. Feedstock Conversion and Refining: Thermo-chemical Conversion of Biomass to Bio-fuels

The Feedstock Conversion and Refining Objective will perform a detailed economic analysis of the performance of a refinery based on pyrolytic processing of biomass into liquid fuels and will provide biochar to other CenUSA researchers. The team concentrates on two primary goals:

- Estimating energy efficiency, GHG emissions, capital costs, and operating costs of the proposed biomass-to-biofuels conversion system using technoeconomic analysis;

- Preparing and characterizing Biochar for agronomics evaluations.

Sub-objective 1. Perform Technoeconomic Analysis

1. **Planned Activities**

   Conduct preliminary literature search to develop plans for process modeling assumptions. Determine most appropriate modeling program and begin model development.

2. **Actual Accomplishments**

   Chemstation's Chemcad® has been selected as the process modeling software to be used. A literature review was completed and the base process model has been constructed as shown in Figure 1. This model contains provisions to simulate traditional fast pyrolysis or in-situ catalytic pyrolysis.

3. **Explanation of Variance**

   No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**

   Additional literature research must be conducted to refine yield assumptions in the process model. Initial yield results from micropyrolysis tests completed by Akwasi Boateng as part of the Feedstock Development Objective (Objective 1) will be compared to published data.

   Publications, Presentations, and Proposals Submitted

   None to report this period.

Sub-objective 2. Prepare and characterize biochar

1. **Planned Activities**

   Laboratory work to analyze the anion exchange capacity of biochars that have aging in aqueous solutions under oxidizing conditions.

2. **Actual Accomplishments**

   Analysis of anion exchange capacity (AEC) for aged biochars was completed. The analysis included chars made from alfalfa, cellulose and corn stover biomass pyrolyzed at 500 and 700°C with control, aluminum, and iron pretreatments. The analysis was done in triplicate, hence a total of 54 samples were analyzed. The results indicate AEC values ranging from 0 to nearly 200 mmol/kg, with higher AEC values for the 700°C biochars relative to the 500°C biochars and significant effects of the metal pretreatments. The

Figure 2. Fast Pyrolysis Process Model Flow Diagram

results also indicate that the aged (oxidized) biochars retained most of their AEC relative to the fresh biochar, which were previously analyzed.

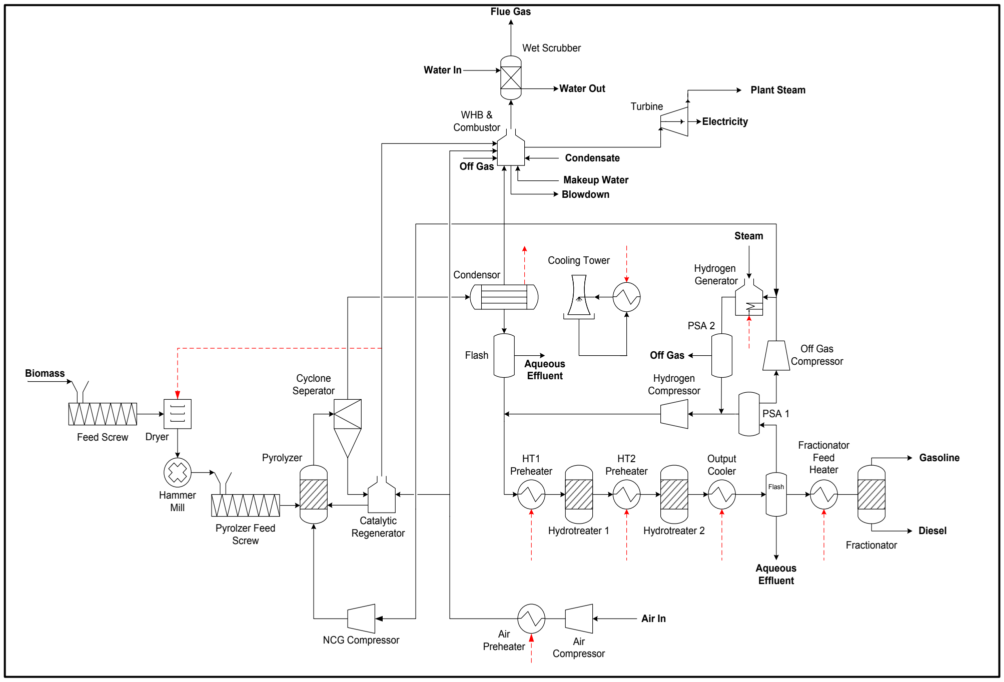

Figure 4. Fast pyrolysis process model flow diagram

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

Data analysis for Bohem titrations will be completed and work will begin on drafting a manuscript. Ash content and X-ray diffraction analysis of inorganic components of biochars are planned.

5. Publications, Presentations, and Proposals Submitted

None.

Objective 6. Markets and Distribution

The Markets and Distribution objective recognizes that a comprehensive strategy that addresses the impacts to and requirements of markets and distribution systems will be critical to the successful implementation and commercialization of a regional biofuels system derived from perennial grasses grown on land unsuitable or marginal for the production of row crops. To create this comprehensive strategy the team focuses on two unifying approaches:

- The study and evaluation of farm level adoption decisions, exploring the effectiveness of policy, market and contract mechanisms that facilitate broad scale voluntary adoption by farmers;
- Estimate threshold returns that make feasible biomass production for biofuels.

1. Planned Activities

Our team anticipated a total of five activities for the first quarter of the second year of the project.

- **2012 Integrated Crop Management Conference**. Deliver a session at the 2012 Integrated Crop Management Conference (2012 ICM) CenUSA Bioenergy Symposium, "Understanding the economics of a system of perennial grasses for bioenergy in the central U.S." (Keri Jacobs, CenUSA Co-Pd).
- **2012 ICM Survey**. Report the findings of the survey administered during the 2012 ICM (Keri Jacobs).
- **Farm-level CRP data**. Continue to push forward progress on access to farm-level CRP data (Keri Jacobs).
- **Spatial model of biomass supply**. Continue development of the spatial model of biomass supply with heterogeneous producers (Richard Perrin, CenUSA Collaborator).
- **Interactions with Industry**. Interact with industry (Du Pont, Deere, and Stine Seeds) on a project to model the use of feedstocks as a fuel source for fast pyrolysis. The business model involves a distributed system of fast pyrolysis that provides as byproducts char and bio-oil. Char will be sold as a soil amendment, and bio-oil will be sold for use in furnaces for heat. The group includes soil scientists, chemical engineers and mechanical engineers (Dermot Hayes, CenUSA Co-Pd).
- Model the aggregate supply curve for switchgrass, wheat straw, and corn stover (Dermot Hayes).

2. Actual Accomplishments

Each of our planned activities for Q1 Y2 has been addressed in some manner. Brief explanations for each are provided here.

- **2012 Integrated Crop Management Conference and Survey**. As a means of identifying the barriers and drivers of implementation of the biomass production system, our team arranged to participate in an Integrated Crop Management (ICM) extension series December 28—29, 2012. Through a collaborative effort with CenUSA participants Jill Euken, Chad Hart, Sorrel Brown, and Rob Mitchell, Keri Jacobs delivered a presentation on the expected costs, returns, and production details of switchgrass as a biomass stock in this Central US region.

- A survey was administered to session participants to gain feedback that will be used to inform our modeling efforts and the policy and market mechanisms necessary to make the system viable. The survey results have been integrated in a report which is available as Exhibit 6. Drivers and Barriers to Perennial Grass Production for Biofuels See Exhibit 7, *Adoption of Switchgrass Production Survey*).

- **Farm-level CRP data**. Our team proposed to the USDA that an MOU be established to permit access to micro-level CRP data for signups 27 through 40 (recent general and continuous signups). These data include parcel-specific information on a type of marginal land that may be used in the project's system. Parcel specific information will be used to develop expectations of switchgrass biomass cost estimates, yields, and expected production penalty of switchgrass relative to competing crops. Our team anticipates a delay of several months before these data will be available to us, if the USDA is able to make them available. There has been no advancement of this activity during this quarter.

- **Spatial model of biomass supply**. Previous studies of cost of production of switchgrass in the region have been collected and updated to provide the cost basis needed for producer decision making. These costs will be adjusted to reflect production costs on marginal cropland. Data from switchgrass yield trials was obtained from 683 trials in the upper Midwest to help identify expected yields and yield variance by agronomic area. The gross average yield was 6.8 Mg/ha, ranging from about 1 to 18 Mg/ha. Further analysis will estimate the effects of region, variety, weather, plot size, etc., on yields obtained. This analysis will be conducted in collaboration with Rob Mitchell and Ken Vogel who are working on objectives 1 (Feedstock development) and 2 (Sustainable feedstock production systems).

  Results from nine recent surveys of producer willingness to contract for biomass production are being studied to obtain quantitative and qualitative information about factors affecting this willingness. This information and preliminary budget analyses will provide the basis for simple questionnaires to obtain more information from producer participants in project activities.

A spatial model of biomass supply with heterogeneous producers has been developed and empirically implemented to reveal how heterogeneity among agronomic circumstances and producer characteristics might affect the cost of securing sufficient quantities of feedstock. Preliminary results suggest that these sources of heterogeneity would increase delivered biomass costs by as much as 20%, an important consideration in evaluating the advantages of on-farm pyrolytic processing versus delivery of biomass to large-scale refining plants. Richard Perrin is collecting switchgrass trial data from states relevant to our study. We expect this will continue into the next quarter.

- **Modeling the aggregate supply curve for switchgrass, wheat straw, and corn stover**. Dermot Hayes continues to work on the regional supply curve for grasses and corn stover using a real options framework. This work will is expected to be ongoing through the year.

3. **Explanation of Variance**

No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**

During the third quarter of year 2, our team will work on the following activities:

- Continue to push forward progress on access to farm-level CRP data (Keri Jacobs).
- Continue development of the spatial model of biomass supply with heterogeneous producers (Richard Perrin).
- Continue to interact with industry (Du Pont, Deere, and Stine Seeds) on a project to model the use of feedstocks as a fuel source for fast pyrolysis. The business model involves a distributed system of fast pyrolysis that provides as byproducts char and bio-oil. Char will be sold as a soil amendment, and bio-oil will be sold for use in furnaces for heat. The group includes soil scientists, chemical engineers and mechanical engineers (Dermot Hayes).
- Continue modeling and analysis efforts of the regional supply curve for grasses and stover using a real options framework (Dermot Hayes).

5. **Publications, Presentations, and Proposals Submitted**

- Keri Jacobs. "Understanding the economics of a system of perennial grasses for bioenergy in the Central United States," Presentation at the Integrated Crop Management Conference, Ames, Iowa, November 28 - 29, 2012.

Objective 7. Health & Safety

The production of bioenergy feedstocks will have inherent differences from current agricultural processes. These differences could increase the potential for workforce injury or death if not properly understood and if effective protective counter measures are not in place.

The Health and Safety team addresses two key elements in the biofuel feedstock supply chain:

- The risks associated with producing feedstocks; and
- The risks of air/dust exposure.

1. Task 1 – Managing Risks in Producing Feedstocks

a. Planned Activities

The team is expanding the collection of the various tasks and responsibilities associated with producing biofeedstocks more slowly now and has placed more focus upon the risk analysis of tasks than upon the identification of tasks. The major headings or grouping of tasks fall under these five areas:

1. Establishment
2. Maintaining
3. Harvest
4. On-site processing and storage
5. Transportation

The implementation of a risk assessment was begun with establishment tasks.

b. Actual Accomplishments

After first examining preliminary injury data sources for establishment tasks to be used in the risk assessment, a change in the procedure of measuring the risk was needed because of the lack of specific data required for analysis. As the production of biofeedstocks has a lack of specific data on injury causation during establishment of biofeedstock, emphasis is being placed on qualitative risk assessment techniques rather than quantitative ones. It is also apparent that the other major grouping of tasks (maintenance, harvest, etc.) will have similar issues with specific injury data. A comprehensive examination of risk assessment techniques is being conducted to determine the best approach to use for establishment, maintaining, harvest, on-site processing and storage, and transportation tasks of biofeedstock production.

Curtis Fielder, a new Ph.D. graduate student, joined our team. He will be working primarily on the risk analysis for tasks associated with producing biofeedstocks.

The team has also established a cooperative arrangement with Dennis Murphy the investigator at Penn State University who is also working with another biofuel CAP project to collaborate in developing a standard to assess risk in these types of tasks.[5]

c. Explanation of Variance

Different risk assessment methods (e.g., energy, job, deviation, or fault tree) are available. Each risk assessment method takes discrete tasks and looks through those tasks for potential danger to personnel and equipment involved in the task. Energy analysis looks at sources of energy within a system; looking for potential contacts of energy with personnel or equipment as hazards to be avoided.

Job and Work Safety Analysis. Job and work safety analysis looks at tasks undertaken by personnel looking for time and tasks during which injury may occur. Corrections to work plans are then made to minimize or eliminate tasks deemed dangerous. Deviation analysis starts with the assumption of a safe method of work and looks for deviations that can/do occur during that work. Once a deviation is identified a determination is made if it represents a potential hazard or a safer method of work.

Fault Tree. A fault tree works from an injury/hazardous event looking for all conditions and combinations of conditions that lead to that event. The best method for use would be determined by a review of results from representative tasks taken from different major grouping of tasks in biofeedstock production. For any of these methods to be effective, the tasks to be analyzed must be defined as clearly as possible, including any equipment or chemicals used for the task.

Since there is not a proven example of which risk analysis method works the best for these agricultural tasks, the team and collaborators at Penn State University both agree that is valuable to expend the time to correctly identify the standard risk method to use in biofeedstock production analysis. The development of a standard risk analysis method would better serve the industry than a series of different approaches applied to evaluating risk of tasks.

d. Plans for Next Quarter

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[5] Dennis Murphy Ph.D. is a Distinguished Professor of Agricultural and Biological Engineering Agricultural Safety and Health at Penn State University and an Extension Team Co-Chair for the Northeast Woody/Warm-season Biomass Consortium (AFRI-CAP) project (www.newbio.psu.edu)

Refinement of the accumulated listing of tasks and responsibilities will continue. Comparisons of risk assessments for handling the evaluation of the various tasks will be made with the expected outcome of determining the standard risk assessment tool to use for tasks in biofeedstock production.

e. Publications, Presentations, and Proposals Submitted

No new publication submitted this quarter.

Previous publication submitted: Schwab, C. V., and M. Hanna. 2012. Master Gardeners' safety precautions for handling, applying, and storing biochar. Cenusa bioenergy publication. ISU University Extension and Outreach, Ames, IA 50011.

2. Task 2 – Assessing Primary Dust Exposure

a. Planned Activities

The locations for dust exposures are compiled and those currently identified are being examined for determination of the most likely place to find the highest exposure rates. This will be the selection process to determine where the pilot analysis of actual dust exposure will take place.

b. Actual Accomplishments

The prioritized list locations for dust exposures were being developed and the primary location to be measured in Year 2 will be identified. The identification of the monitoring equipment needed to take dust samples was started.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

Needed monitoring equipment will be identified and obtained to conduct the pilot study. Approvals for human subjects and procedures will be established.

e. Publications, Presentations, and Proposals Submitted

None to report this period.

OUTREACH AND EXTENSION

Objective 8. Education

The Education Objective seeks to meet the future workforce demands of the emerging Bioeconomy through two distinct subtasks, as follow:

- To develop a shared bioenergy curriculum core for the Central Region
- To provide interdisciplinary training and engagement opportunities for undergraduate and graduate students

Subtask 1 is curriculum development. Subtask 2A is training undergraduates via an 8-week summer internship program modeled on the highly successful NSF REU (research experience for undergraduates) program. Subtask 2B is training graduate students via a 2-week summer intensive program modeled on a highly successful industry sponsored intensive program in biorenewables the team led in 2009. Subtask 2C is training graduate students via a monthly research webinar. The next portion of this report is broken into subtasks.

Subtask 1: Curriculum Development

1. Planned Activities

- **Module 2. Perennial Grass Establishment and Management**

  Complete internal review and submit to *Journal of Natural Resources and Life Sciences Education* for peer review.

- **Module 3. Harvesting Systems for Bioenergy Grasses**

  Complete internal review and submit to *Journal of Natural Resources and Life Sciences Education* for peer review.

- **Module 4. Storage Systems for Bioenergy Grasses**

  Develop module content in PowerPoint and begin module development activities with Amy Kohmetscher (CenUSA Collaborator).

- **Module 5. Integrating Bioenergy Production into Current Systems**

  Complete module development activities with Amy Kohmetscher.

- **Module 6. Markets and Distribution**

  Complete development of content in PowerPoint and begin module development activities with Amy Kohmetscher.

- **Module 7 – Overview Module (lead author John Guretzky)**

  Complete outline of remaining content.

2. Actual Accomplishments

We have made changes to the module format for ease in publishing the content.

- **Module 1. Perennial Grass Physiology, Growth, and Development.** Status of components (Lead author John Guretzky, CenUSA Collaborator).

  The **Seedling Emergence** Activity has been accepted for publication in *Natural Science Education*.

- **Module 2. Perennial Grass Establishment and Management**. (Lead author John Guretzky)

  ✓ Initial internal review completed and edits made to the module.

  ✓ Edited and completed video demonstration on use of frequency grid to determine perennial grass establishment success. The video, How to Measure Stand Establishment Using a Grid, is available on the CenUSA website and on the CenUSA YouTube and Vimeo channels.[6]

- **Module 3. Perennial Grass Harvest Management**. (Lead authors Pat Murphy, CenUSA CoPd and Iman Beheshti Tabar)

  ✓ Content has been converted to an ADA compliant format.

  ✓ The edited content is ready for final internal review.

- **Module 4. Storage Management.** (Lead authors Pat Murphy and Iman Beheshti Tabar)

  Completed outline of module content.

- **Module 5. Integrating Bioenergy Production into Current Systems**. **(**Lead author Nicole Olynk)

  We are recording Camtasia lectures from PowerPoint slides.

- **Module 6. Markets & Distribution Module**. (Lead author Corrine Alexander)

  We are recording Camtasia lectures from PowerPoint slides.

- **Module 7. Introduction to Perennial Grasses as a Bioenergy Feedstock**. (Lead author John Guretzky)

[6] www.cenusa.iastate.edu/Content/files/How_to_Measure_Stand_Establishment_Using_a_Grid.mp4; www.youtube.com/user/CenusaBioenergy; and https://vimeo.com/cenusabioenergy

Finished the conversion of the webinar into a lesson.

3. **Explanation of Variance**

Significant changes in the format of Module 3 needed to be made for ADA compliance prior to submitting the module for internal and external review. These changes have been made and will not affect the schedule, plan of work or budget.

4. **Plans for Next Quarter**

- **Module 3. Perennial Grass Harvest Management**

  Complete internal review and submit to *Journal of Natural Resources and Life Sciences Education* for peer review

- **Module 4. Storage Management**

  Continue module development activities with Amy Kohmetscher.

- **Module 5. Integrating Bioenergy Production into Current Systems**

  Continue module development activities with Amy Kohmetscher.

- **Module 6. Markets & Distribution Module**

  Continue module development activities with Amy Kohmetscher.

- **Module 8. Ecosystems Services for Dedicated Bioenergy Crops**

  Begin outlining module content

5. **Publications, Presentations, and Proposals Submitted**

None to report this period.

Subtask 2A: Training Undergraduates via Internship Program

1. **Planned Activities**

- Finish solicitation of projects from faculty.
- Promote the undergraduate internship program and encourage application submissions, working with lists of underrepresented minority students generated by ISU graduate college, lists of department chairs at relevant disciplines in universities across the Midwestern region, and through job-posting boards at regional institutions.
- Refresh content on website to reflect 2013 program and post 2013 application.

- Begin accepting applications and field inquiries about the program.

2. Actual Accomplishments

- Obtained research project descriptions from faculty.
- Promoted the undergraduate internship program to encourage application submissions as detailed above.
- Created detailed schedule for the 2013 undergraduate internship program.
- Website content updated with 2013 project and logistic information as well as new 2013 application.
- Applications are accepted and inquiries regarding the program are answered.
- Secured on-campus housing for students who will be hosted by Iowa State University faculty.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Continue to promote the undergraduate internship program and encourage application submissions through March 15, 2013 application deadline.
- Centrally vet and rank applicants based on letter of interest, academic achievement, previous research experience and letters of recommendation.
- Pool of likely candidates given to faculty hosts for review during week of March 18 with selection decisions by March 25.
- First offers to students on March 25, second offers to students on April 1 with cohort (11 students) finalized on April 15.
- Arrange travel for accepted students.
- Secure housing for students who will be placed with faculty mentors at partner institutions.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Subtask 2B – Training Graduate Students via Intensive Program

1. **Planned Activities**

- Get tentative headcount from entire program.
- Finalize schedule.
- Get clear learning objectives for each day of content from program lead.
- Line up housing and facilities for program.

2. **Actual Accomplishments**

- Worked with central administrative staff and faculty to determine headcount for the program.
- Worked with faculty to create a ten-day schedule (June 9 – 19, 2013) for the intensive program at the Iowa State campus to include lectures, recitation periods, and field experiences covering each objective area.
- Reserved on-campus housing for graduate students and meeting rooms for the program delivery.

3. **Explanation of Variance**

Not applicable.

4. **Plans for Next Quarter**

- Determine final list of intensive program attendees.
- Provide faculty with full program agenda and details of each objective leaders' responsibilities for their portion of the intensive program.
- Arrange travel for graduate student participants and faculty presenters.

5. **Publications, Presentations, and Proposals Submitted**

None to report this period

Subtask 2C –Subtask 2C – Training Graduate Students via Monthly Research Webinar

1. **Planned Activities**

- Organize the first three research webinars.

- ✓ Objective 1 – February 22
- ✓ Objective 2 – March 29
- ✓ Objective 3 – April 25

2. Actual Accomplishments

- Held research webinar on February 22
  - ✓ *Twenty Years of Switchgrass Improvement to Create a Dedicated Bioenergy Crop* by Michael Casler.
  - ✓ *Genomic Selection to Improve Biomass Yield of Switchgrass* by graduate students Emily Rude and Guillaume Ramstein.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Deliver research webinars for Objective 2 -Sustainable Feedstock Production Systems and Objective 3 – Feedstock Logistics.
  - ✓ March 29 – Objective 2. Jeff Volenec, Rob Mitchell, and David Laird are working with their graduate students on content and delivery.
  - ✓ April 26 – Objective 3. Stuart Birrell and Kevin Shinners are working with their graduate students on content and delivery.
- Begin organization of next three webinars (Objectives 4-6) to be delivered May – July 2013.

5. Publications, Presentations, and Proposals Submitted

- Guretzky, J., Kohmetscher, A. and Namuth-Covert, D. (2013) Grass Seed Structure and Seedling Emergence. Nat. Sci. Educ. 42:1-1 doi:10.4195/nse.2012.0018w.

Objective 9. Extension and Outreach

The Outreach and Extension Objective (Objective 9) serves as CenUSA's link to the larger community of agricultural and horticultural producers and the public-at-large. The team delivers science-based knowledge and informal education programs linked to CenUSA Objectives 1-7.

The following teams conduct the Outreach and Extension Objective's work:

- **Extension Staff Training/eXtension Team**

  This team concentrates on creating and delivering professional development activities for Extension educators and agricultural and horticultural industry leaders.

- **Producer Research Plots/Perennial Grass Team**

  This team covers the areas of:

  ✓ Production, harvest, storage, transportation;

  ✓ Social and community impacts;

  ✓ Producer and general public awareness of perennial crops and Biochar agriculture;

  ✓ Certified Crop Advisor training.

- **Economics and Decision Tools Team**

  The Economics and Decision Tools Team will focus on the development of crop enterprise decision support tools to analyze the economic possibilities associated with converting acreage from existing conventional crops to energy biomass feedstock crops.

- **Health and Safety Team**

  This team integrates its work with the Producer Research Plots/Perennial Grass and the Public Awareness/Horticulture/eXtension 4-H and Youth teams (See Objective 7. Health and Safety).

- **Public Awareness/Horticulture/eXtension/4-H and Youth Team**

  This team focuses on two separate areas:

  - **Youth Development.** The emphasis is on developing a series of experiential programs for youth that introduce the topics of biofuels production, carbon and nutrient cycling, and biochar as a soil amendment.

  - **Broader Public Education/Master Gardener.** These programs acquaint the non-farm community with biofuels and biochar through a series of outreach activities using the Master Gardener volunteer model as the means of introducing the topics to the public.

- **Evaluation/Administration Team**

  This team coordinates CenUSA's extensive extension and outreach activities. The team is also charged with developing evaluation mechanisms for assessing learning and behavior change resulting from extension and outreach activities, compiling evaluation results and preparing reports, and coordination of team meetings.

1. Extension Staff Training/eXtension Team

a. Planned Activities

To continue the review process for CenUSA articles, videos, and webinars so that they can be added to the CenUSA resource library and the eXtension web site.

b. Actual Accomplishments

Production of CenUSA Extension "on-line" learning articles hit stride this quarter. We are continuing the review process. Accomplishments include:

- Produced the extension fact sheet/article "Optimizing Harvest for Perennial Grasses" which is now available on the CenUSA website (www.cenusa.iastate.edu/PublicFile/_GetPublicFile?publicFileId=52)

- Finished review of article "Logistical Challenges to Switchgrass (*Pancium virgatum* L. as a Bioenergy Crop."

- Produced the video "Optimizing Harvest of Perennial Grasses for Biofuel. The video is available on the CenUSA web site, the CenUSA Vimeo Channel (https://vimeo.com/57621501) and the CenUSA YouTube Channel (http://youtu.be/NMt5Ct-65-Y).

- **CenUSA Video/Webinar Statistics**.

  - **Vimeo Channel**. During this quarter, the 22 CenUSA videos archived on Vimeo have had 65 plays, or users who viewed the video from the site. The 22 videos also had 4,370 loads. This means 4,370 saw the video, but did not play it. In addition, CenUSA videos were embedded on various web pages 3,205 times this quarter, meaning that people are sharing the CenUSA videos with others through their own pages.

  - 10 users downloaded a copy of a CenUSA video from the Vimeo site. This means the video was saved to their hard drive (users do this because they have limited Internet connectivity which does not allow for live streaming of a video. Once the video is downloaded, it is available on their computer to watch at their convenience.

- All total this quarter, CenUSA web-based materials had 75 solid contacts and 7,395 people were exposed to the CenUSA project even though they did not explicitly view the video or webinar.

c. Explanation of Variance

The CenUSA Extension team for on-line learning articles, videos, and webinars underestimated the time required to receive reviews on articles and organize speakers for webinars. While the team was able to finish articles, only planning for webinars occurred. A webinar is scheduled for the third quarter of 2013. A video related to planting perennial grasses, while produced and edited, is still in need of a few final revisions.

While the articles created by the extension team are available on the CenUSA web site, eXtension requires a completely separate review process that we are working to coordinate. Once eXtension review is completed, the articles written in the second quarter will be available on the eXtension web site.

d. Plans for Next Quarter.

- Provide two CenUSA seminars at the First National Extension Energy Summit in Colorado April 29-May 1, 2013.
- Organize and plan for CenUSA and Iowa State University to host the Second National Extension Energy Summit in Iowa in 2014, and write and submit a grant application to NIFA for financial support for the summit (Jill Euken Co-Pd and Pam Porter, CenUSA Collaborator)
- Host a webinar for Extension Educators, producers, and industry professionals.
- Complete an extension article related to hydro-ecological and water quality benefits of perennial grasses.
- Finish reviewing the planting video and make it available to the public.
- Finish up eXtension reviews of articles and videos for posting on eXtension site.

e. Publications, Presentations, Proposals Submitted

2. Producer Research Plots/Perennial Grass Team

a. Planned Activities

- Recruit farmers for a second set of on-farm demonstration plots to be established in Indiana, Iowa, Nebraska, and Minnesota in the spring of 2013.
- Meet with the Minnesota Corn Growers Association to discuss CenUSA project objectives and the challenges associated with switchgrass establishment on marginal lands.
- Plan for field days to be held in June 2013 in Indiana and Iowa.
- Design a CenUSA Mini-series (four different CenUSA sessions) for the *Iowa Integrated Crop Management Conference* in December 2012.
- Work with the Purdue Exhibit Center to continue development of the CenUSA Bioenergy Grass exhibit.

b. Actual Accomplishments

- Farmers have been recruited for the second set of on-farm demonstration plots to be established in Indiana, Iowa, Nebraska, and Minnesota in 2013.
- Planning continues for June 2013 Indiana and Iowa field days.
- Four CenUSA sessions were held at the *Iowa Integrated Crop Management Conference*:
  - ✓ Chad Hart (CenUSA Collaborator) provided an outlook meeting for cropping production costs and expected returns, including information about pending nutrient management strategies and opportunities for perennial grasses for biofuel production. One hundred twenty farmers and agriculture industry leaders attended.
  - ✓ Kerri Jacobs hosted two sessions which were attended by 147 farmers and agriculture industry leaders. Jacobs provided an overview of the CenUSA vision and administered a survey to learn about their attitudes regarding production of perennial grasses for biofuels. See Exhibit 6 for survey results.
  - ✓ Rob Mitchell presented two sessions to a total of 56 people on the topic of perennial grass establishment.
  - ✓ David Laird (CenUSA CoPd) hosted two sessions, sharing current biochar research results with a total of 220 farmers and agriculture industry leaders.
- John Hay (CenUSA Collaborator) hosted sessions for 30 farmers at the *Nebraska Farm Machinery Show*.

- CenUSA Extension project personnel hosted a workshop for the *Indiana* Biomass *Energy Working Group* on the topic of the development of biofuels for the aviation industry. The working group is open to the public and is made up of diverse stakeholders from industry, government, trade organizations, universities, and entrepreneurs from throughout Indiana. The working group's goal is to create a climate in the state of Indiana that can foster the growth of a viable renewable energy industry, protect Indiana's environment, and provide energy security and green jobs in Indiana. CenUSA's goal in participating in this program was to educate participants about the research and prospects for the adoption of biofuels by the aviation industry. This could include the use of fuels derived from energy grasses related to the CenUSA project (See Exhibit 8. Possibilties for Aviation Biofuels in the Midwest).

  There were 55 participants in the program (68% male, and 32% female). Thirty-two percent indicated they were "University faculty/staff", 24% "Extension Professionals," 20% of participants "Business Owners/Enterpreneuers", 16% "Non-Profit Organizations," and 8% "Government Employees. About 86% were between the ages of 25 and 45, 10% were over the age of 55, and 4% were aged 18 to 25.

  Participants provided following information at the conclusion of the program.

  ✓ A strong majority of 57.7% stated they strongly agreed with the statement "The information provided me with new knowledge." 42.3% agreed with the statement, and 3.% disagreed.

  ✓ 46.2% of respondents strongly agreed, 50.0% agreed, and 3.8% disagreed with the statement "The new ideas presented will be helpful to me in my business."

  ✓ 26.1% strongly agreed, 65.2% agreed, 8.7% disagreed with the statement "The program provided me with new skills I would like to apply to my business."

  ✓ 29.2% strongly agreed, 62.5% agreed, 8.3% disagreed with the statement "The new skills will be useful in my business."

  ✓ **CenUSA Visual Display.** A new CenUSA visual display was rolled out at this event. The display was well received, with one participant representing the commercial aviation alternative fuels industry indicating he would like to see it exhibited at future aviation industry events.

    The table top display included:

    - Samples of switchgrass, big bluestem, and indiangrass seeds

- Plant material with biochar,
- A question and answer interactive display about the history, research, and future of bioenergy crop production, and
- Scrolling display units describing the CenUSA program.

Figure 5. CenUSA Bioenergy Visual Display (Vertical)

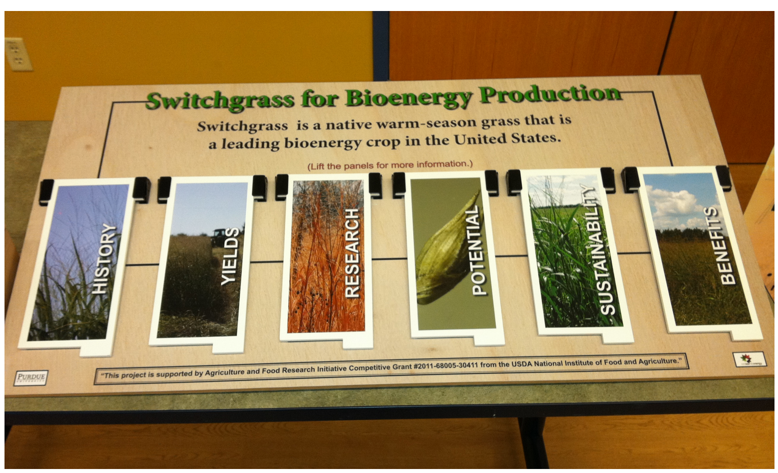

Figure 6. CenUSA Display

✓ **CenUSA Bioenergy Extension Exhibit**

- Samples of bioenergy grasses including switchgrass, big bluestem, and indiangrass.

  - Box containing biochar and grass seed samples.
  - Interactive Switchgrass information board.
  - Dual scrolling display units addressing the "Why, Where, and What" context of bioenergy grass production along with benefits.

- Bob Wells and Jim Jensen (CenUSA Collaborators) included information about CenUSA in winter outlook meetings, meetings for women landowners and meetings for community service groups.

c. Carl Rosen (CenUSA Collaborator) met with 60 Minnesota Corn Growers to discuss transitioning marginal land in Minnesota to perennial grasses for use in biofuel production. He detailed the CenUSA vision, use of grasses as a biomass crop to provide ecosystem services such as reduced runoff and maintenance of soil OM and structure.

d. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

e. Plans for Next Quarter

- **Purdue University**

  - ✓ Participate in the Purdue Extension sponsored *Small Farms Conference* on March 1-2, 2013. Keith Johnson (CenUSA Collaborator) will present CenUSA perennial grass information and we will host a CenUSA session on utilization of marginal crop and grass lands for energy crop production.
  - ✓ Visit Indiana FFA Center at Trafalgar to plan possibility of seeding plots and having an exhibit at the center.
  - ✓ Establish demonstration plots at Larry Pfug farm in Gibson County, Indiana.
  - ✓ Evaluate demonstration plots sown at the Jerry Sweeten farm in 2012 and the Throckmorton-Purdue Agricultural Center, and follow through with appropriate management.
  - ✓ Plan the June 21, 2013 forage tour. One of the tour stops will be at the CenUSA plots at the Sweeten farm.
  - ✓ Meet with Purdue University team members to keep appraised of results and to help in planning the CenUSA annual meeting.
  - ✓ Complete Extension publications started in previous quarter.

- **Nebraska CenUSA Extension**
  - ✓ Make necessary preparations to burn CenUSA plot established in 2012.
  - ✓ Burn plot in mid-March time frame.
  - ✓ Assess emergence percentage of 2012 grass seedings.
  - ✓ Determine if reseeding/interseeding is required on 2012 plot. If needed, perform in mid-to-late April.
  - ✓ Spray herbicide treatments.
  - ✓ Locate second 2013 CenUSA plot site and secure usage agreement with the cooperator.
  - ✓ Make preparations for 2013 seeding of second CenUSA Nebraska plot.
  - ✓ Seed second CenUSA plot in mid-to-late April 2013.
  - ✓ Spray herbicide treatments.
- **Iowa CenUSA Extension**
  - ✓ Include information about CenUSA in three pasture walks and in 7 summer lease meetings.
  - ✓ Burn 2012 on-farm demonstration plots, access emergence, determine path forward (rescue or re-establish).
  - ✓ Establish 2013 on-farm demonstration plot.
- **Minnesota CenUSA Extension**
  - ✓ Burn the 2012 demonstration plots at Elko. Re-seed areas damaged in 2012 due to extreme rain events followed by extreme drought.
  - ✓ Establish a second demonstration plot in Lamberton. These plots will be close to the Southwest Research and Outreach Center.
  - ✓ Work with Southwest Research and Outreach Center to schedule field days once plots are established.

f. Publications, Presentations, Proposals Submitted

See previous section "Plans for Next Quarter."

3. Economics and Decision Tools

Realizing heightened interest in mitigating the environmental impacts of row crop production in the Midwest, CenUSA has reached out to the Hypoxia Task Force co-Chair, Iowa Secretary of Agriculture Bill Northey (see: http://water.epa.gov/type/watersheds/named/msbasin/index.cfm) to discuss how CenUSA research, education and outreach (establishing perennial grasses on marginal lands and a distributed set of pyrolyzers to process the grass into biofuels and bioproducts) can be leveraged to support the Task Forces' goal of reducing and controlling hypoxia in the Gulf of Mexico.

Bill Lazarus, CenUSA Extension Economics team member, has developed the *Watershed Nitrogen Reduction Planning Tool (NBMP.xlsm) for Comparing the Economics of Practices to Reduce Watershed Nitrogen Loads*. This tool is being used to help states that drain into the Gulf evaluate if, where and how to use perennial grasses to mitigate nitrogen and phosphorus loads in the water (for additional information about the NBMP, see: http://faculty.apec.umn.edu/wlazarus/documents/nbmp_overview.pdf). This tool will be one of the resources discussed at a CenUSA-hosted workshop for the Hypoxia Task Force and environmental and agricultural groups in the fall of 2013.

4. Health and Safety

a. Planned Activities

Hire a graduate student to begin safety and hazards analysis.

b. Actual Accomplishments

Curtis Fielder enrolled in graduate school and was hired as graduate student for the CenUSA safety component.

c. Variance

No variance has been experienced and accomplishments are on schedule.

d. Publications, Presentations, Proposals Submitted

None to report this period.

5. Public Awareness/Horticulture/eXtension/4-H and Youth Team

1. Youth Development – Planned Activities

- Plan a 4-H science workshop to be held in Indiana in the summer of 2013.

- Develop e-learning modules for high school aged learners.
- Get biochar activities into second Indiana classroom at local middle school utilizing relationships established during the previous quarter.
- Complete youth Biofuel Fact Sheets.

2. Youth Development – Actual Accomplishments

- Biochar activities in two Lafayette, Indiana junior high school 8th grade science classrooms.
- Purdue biofuel fact sheets drafts are currently in final editing.
- Purdue started creating biofuel e-learning modules for high school aged students.
- Continued planning biofuel-related 4-H science workshops, including conference call between IN and Iowa CenUSA Extension youth teams.
- Iowa continued the development of the youth biochar curriculum.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

- Complete the high school e-learning module working digital prototype.
- Meet with state FFA executive director to discuss plans for educational switchgrass test plot that could be utilized during FFA camps.
- Have digital prototype of e-learning module reviewed.
- Continue planning for the summer 4-H science workshop.
- Write up paperwork for summer 2013 intern.

5. Publications, Presentations, Proposals Submitted

Fact Sheets are in the editing stage.

3.B Broader Public Education/Master Gardener Program

a. Planned Activities

Provide CenUSA developed educational resources to Master Gardeners (MG), Junior Master Gardener (JMG) Leaders, and other community educators through local and state continuing education opportunities, such as State Master Gardener Conference and JMG training.

b. Actual Accomplishments

- **CenUSA Biochar Demonstration Gardens.** We compiled a comprehensive report covering the biochar gardens in the three Minnesota CenUSA Master Gardener sites (See Exhibit 8. 2012 CenUSA Biochar Demonstration Gardens (Minnesota)).
    - Julie Weisenhorn, Kurt Spokas, and Lynne Hagen (CenUSA Collaborator) met to go over draft of the 2012 biochar garden report.
- **New Biochar Garden Site**. Julie Weisenhorn secured a new biochar site near Lake Mille Lacs on the Fond du Lac Indian Reservation. Ground breaking will take place in 2013. Data from that site will be included with the other three sites in 2013.
    - Procured donation for additional biochar from Royal Oak Charcoal Company for the Lake Mille Lacs site.
- Collected "Ask an Expert" questions from the Master Gardener eXtension site; David Laird wrote responses to the questions and they are posted on the Master Gardener eXtension site.
- Summarized evaluation done at the Iowa CenUSA Master Gardener sites and drafted a Fact Sheet summarizing the data. The fact sheet will be completed during the third quarter.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

- Continue with the eXtension Master Gardener blog postings. (http://blogs.extension.org/mastergardener/tag/2012-cenusa-bioenergy-biochar-test-garden-research/)
- Purchase seeds and locate a grower to start them.
- Recruit new project volunteers.
- Revamp data collection procedures and training materials for volunteers.

- Record Kurt Spokas (ARS) biochar presentation for training CenUSA Master Gardener volunteers and upon completion, schedule Minnesota volunteer training.
- Perform analytics on eXtension biochar blog.

e. Publications, Presentations, Proposals Submitted

- 2012 CenUSA Biochar Demonstration Gardens (Minnesota) (See Exhibit 8)
- "Ask an Expert" questions are currently under review by eXtension.

6. Evaluation and Administration

a. Planned Activities

- Continue to develop evaluation instruments and strategies for CenUSA Extension team members, and summaries of CenUSA data.
- Collect and assemble Outreach and Extension material for the CenUSA quarterly reports.

b. Actual Accomplishments

- Continue to develop evaluation instruments and strategies for CenUSA Extension team members, and summaries of CenUSA data.
- Plan and conduct a workshop for representatives of companies developing thermochemical processing technologies, CenUSA leaders, agricultural producer groups to develop a roadmap for commercializing thermochemical processing using herbaceous biomass produced in the Midwest.
- Collect and assemble Outreach and Extension material for the CenUSA quarterly reports.

c. Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter:

- Draft and submit grant application to NIFA to support the *Second Annual Extension Energy Summit* to be hosted by CenUSA and Iowa State University in 2014.
- Develop relationship with *Hypoxia Task Force*. (See Economics and Decision Tools, above).

- Assist Jason Hill (CenUSACo-Pd) with planning for the CenUSA Workshop with the *Hypoxia Task Force* and agricultural and environmental leaders. This workshop is tentatively set to be held in the fall of 2013.

- Continue evaluation efforts to document knowledge gained by participants in CenUSA Outreach and Extension activities.

e. Publications, Presentations, Proposals Submitted

See Fact Sheets referenced in sections above.

cenusa bioenergy

"Our vision is to create a regional system for producing advanced transportation fuels derived from perennial grasses grown on land that is either unsuitable or marginal for row crop production. In addition to producing advanced biofuels, the proposed system will improve the sustainability of existing cropping systems by reducing agricultural runoff of nutrients and soil and increasing carbon sequestration."

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Exhibit 18

cenusa bioenergy

Quarterly Progress Report

Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform

May 2013

Agriculture and Food Research Initiative Competitive Grant
No. 2011-68005-30411

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NOTICE

This quarterly report was prepared by Iowa State University and CenUSA Bioenergy research colleagues from Purdue University, United States Department of Agriculture-Agricultural Research Service, University of Illinois, University of Minnesota, University of Nebraska, Lincoln, University of Vermont, and the University of Wisconsin in the course of performing academic research supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the United States Department of Agriculture National Institute of Food and Agriculture ("USDA-NIFA).

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Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (AFRI-CAP 2010-05073)

Quarterly Report: February 1, 2013 – April 30, 2013

PROJECT ADMINISTRATION

- **Project Organization and Governance Accomplishments**

  Ken Moore (Professor, Iowa State University) continues as the CenUSA Bioenergy Project Director. Anne Kinzel (Chief Operating Officer) and Val Evans (Financial Manager) handle project coordination, communication, and data sharing among the project's research partners (Purdue University, University of Wisconsin, Madison, University of Minnesota, Twin Cities, University of Nebraska, Lincoln, University of Illinois, Champaign, University of Vermont-Burlington, and the USDA Agricultural Research Service). Kinzel is also responsible for the day-to-day project management including the preparation of quarterly and annual progress reports, meetings, and maintenance of the project's public face (website/social media outlets). Evans continues to be responsible for all project financial activities, including the development and implementation of administrative policies and procedures and the management of subcontracts with the projects research partners to ensure effective financial operation and oversight of the project. In addition, Evans has assumed responsibility for coordinating planning of the 2013 CenUSA Annual Meeting with Iowa State University's Conference Planning Services and host Jeff Volenec (Purdue University).

  As we enter CenUSA's third year each of our nine CenUSA objectives is showing satisfactory progress in meeting CenUSA's deliverables schedule. This quarter has seen a number of exciting project governance activities take place.

- **Featured Third Quarter Activities**

  - **Project Reapplication – Year 3**. The CenUSA original award terms and conditions (August 2011) require us to submit a separate application for Project Years 3, 4 and 5. Given the size and the multi-discipline and multi-institution nature of the project this was not an inconsequential endeavor. Each of the project's nice separate objectives participated in preparing the required materials. While the task did take time it also allowed us to make a mid-project assessment and measure our accomplishments relative to the project's deliverables schedule. This review confirms that much has been accomplished and that we remain on track to complete our objectives by the end of the fifth year.

  - **Delivering Feedstock to Industry**. At the December 2012 *Roadmap to Commercialize Thermochemical Biofuels and Bio-Processing in the Midwest* workshop we made agreements with industry partners to provide them with feedstock in exchange for a commitment to sharing data from their conversion process. The arrangements for the types of feedstock desired were completed and we have been delivering the feedstocks and will continue to do so into early in the fourth quarter of this year, presumably in May and June 2013.[1]

- **2013 CenUSA Annual Meeting**. All preparations for the 2013 CenUSA Annual Meeting (July 30 – August 2, 2013) hosted by Jeff Volenec and Purdue University are on track. We have an excellent agenda (See Exhibit 1) and to date registration has been very good. We anticipate that all objectives will be well represented as will the project's Advisory Board. We have also invited a number of industry professionals who attended the December workshop as well as the project directors of the other NIFA-CAP projects. The NIFA-CAP project directors will be participating in a panel to educate our CAP collaborators on the status of our fellow CAP grantees. As at our two previous annual meetings our Advisory Board will also be providing extensive feedback in the form of a panel discussion and followed up with a written comment report.[2]

- **Environmental Interest Group Workshop**. CenUSA will host a workshop in Minneapolis, Minnesota for environmental interest groups. The meeting is tentatively scheduled for the 23-25th of September 2013. CenUSA CoPd Jason Hill (System Performance Metrics, Data Collection, Modeling Analysis, and Tools) and Jill Euken (CoPd, Extension and Outreach) will lead this effort. The meeting will be jointly held with the Mississippi River Basin Watershed Nutrient Taskforce (http://water.epa.gov/type/watersheds/named/msbasin/index.cfm).

  Hill and Euken have applied for a USDA-NIFA conference grant to support the event. This meeting was a direct outcome from discussions that took place at the CenUSA Bioenergy mid –year meeting that took place immediately following the Commercialization Workshop.

- **Advisory Board**

  The Advisory Board continues to provide valuable feedback and advice to the research team. Advisory Board members have been attending the new monthly research seminars. The Advisory Board will also be attending the 2013 Annual Meeting. Early indications indicate there will be an excellent Board turnout at the Annual Meeting.

- **Coordination, Collaboration, and Communication**

[1] The workshop was held December 11-12, 2012 at Iowa State University in Ames, Iowa. A full description of the workshop has been provided in the second quarter report.
[2] As we have done in previous project years we will hold a special online meeting with the Advisory Board and the project leadership team to discuss the Advisory Board's written comments.

- **Executive Team Meetings and CenUSA Research Seminar.** The Co-Project directors representing each of the nine objectives continue to meet monthly with Ken Moore, Anne Kinzel and Val Evans via online meetings held in CenUSA's dedicated Adobe Connect meeting room. The virtual meeting room allows for documents to be viewed by all participants, enhancing communications and dialogue between participants. Tom Binder, the Advisory Board chair also attends these meetings, to ensure there is an Advisory Board presence during these important project gatherings.

- **Objective and Team Meetings.** All nine CenUSA Objectives continue to participate in scheduled and ad hoc meetings using the CenUSA Adobe Connect meeting room or in face-to-face meetings. The five Extension and Outreach Objective teams also meet via Adobe Connect or face-to-face gatherings.[3]

- **Communication Platforms.** CenUSA continues to focus on expanding the quality and sophistication of the CenUSA website (www.cenusa.iastate.edu) and other social media outlets. Our website (http://www.cenusa.iastate.edu) has been upgraded and continues to provide an excellent public presence for the project.

- **Webinars/Videos**. Our project webinars and videos are disseminated via three separate sites to provide multiple outlets to view CenUSA-webinars and videos: 1) the CenUSA website, 2) a CenUSA Bioenergy "YouTube Channel" (www.youtube.com/user/CenusaBioenergy) and 3) a CenUSA Bioenergy Vimeo site (https://vimeo.com/cenusabioenergy) to provide an additional outlet to view CenUSA webinars and videos.

  We added two videos to our sites this quarter:

  ✓ *2013 Switchgrass Planting Practices for Stand Establishment.*
  ✓ *2013 Thermochemical Conversion of Biomass to Drop- in Biofuels*

- **Financial Matters.** The Administrative Team continues to monitor all project budgets and subcontracts to ensure adherence to all sponsor budgeting rules and requirements.

- **Program Matters.** We will continue to focus on project coordination, communication, meetings and data sharing across Objectives, and on reaching the revised timelines milestones.

[3] The teams are Broader Public/Master Gardener/Youth Programs, Economics and Decision Tools, Evaluation/Administration, Extension Staff Training/eXtension, Health and Safety, and Producer Research Plots/Perennial Grass. For more information see www.cenusa.iastate.edu/Outreach.

GERMPLASM TO HARVEST

Objective 1. Feedstock Development

Feedstock Development focuses on developing perennial grass cultivars and hybrids that can be grown on marginal cropland in the Central United States for the production of biomass for energy. In 2012, the focus was on the establishment of new breeding and evaluation trials.

1. **Significant Accomplishments Summary**

- **Publications**

  ✓ One journal paper on switchgrass selection criteria for biomass yield was accepted for publication in *Crop Science* (Mike Casler – ARS Madison): Price, D.L. and M.D. Casler. 2013. Predictive relationships between plant morphological traits and biomass yield in switchgrass. *Crop Sci*. (in press). Summary**:** Switchgrass is undergoing transformation to become a perennial bioenergy crop. Breeding for increased biomass yield per acre is a significant component of this transformation. Because most switchgrass breeding is done in large nurseries containing tens of thousands of plants that are visually evaluated under relatively non-competitive conditions, breeding for biomass yield is relatively inefficient. This research showed that tillering (spreading) traits are typically the most important for predicting biomass yield of plants grown under non-competitive conditions, but that plant height and leaf area traits are more important for plants grown under real-world competitive conditions. These results will help to refine the objectives of switchgrass breeding programs, improving their efficiency, and increasing the rate of progress toward higher yielding varieties.

  ✓ Two journal papers on inheritance of secondary traits affecting yield in switchgrass have been submitted for publication and are currently in journal review (M. Casler, ARS-Madison): Price, D.L. and M.D. Casler. 2013. Inheritance of secondary morphological traits for among-and-within-family selection in upland tetraploid switchgrass. *Crop Sci.* (in review). Summary: Efforts to increase the rate of progress for increasing biomass yield of switchgrass are focusing on an increased emphasis of morphological traits related to yield, including flowering time, plant height, and number of stems. Research demonstrated that each of these traits has a positive heritability value, indicating that there is significant genetic variation that can be utilized in a breeding program. Because flowering time had a very high heritability value, results suggested that this trait be given the greatest emphasis to select the best plants within the best families. These results will be of direct value to switchgrass breeding programs with improvement in biomass yield as a major goal.

- ✓ Price, D.L. and M.D. Casler. 2013. Divergent selection for secondary traits in upland tetraploid switchgrass and effects on sward biomass yield. BioEnergy Res. (in review). **Summary:** Efforts to increase the rate of progress for increasing biomass yield of switchgrass are emphasizing morphological traits related to yield, including flowering time, plant height, and number of stems. This study was conducted to validate predictions made in two previous studies that selection for increased plant height, increased number of stems, and later flowering would be effective mechanisms for increasing biomass yield of switchgrass. Contrary to expectations, selection for taller plants or plants with more stems failed to increase biomass yield of the progeny, despite evaluation of progeny at five locations. However, selection for later flowering was highly effective, resulting in a 25% difference in biomass yield between early and late-flowering progeny. These results confirm previous results and expectations that switchgrass for biomass production in the northern USA should be moved toward later flowering varieties. These results will have direct impact on breeding programs, agronomy research programs, and outreach programs that serve the biomass and biofuel industry.

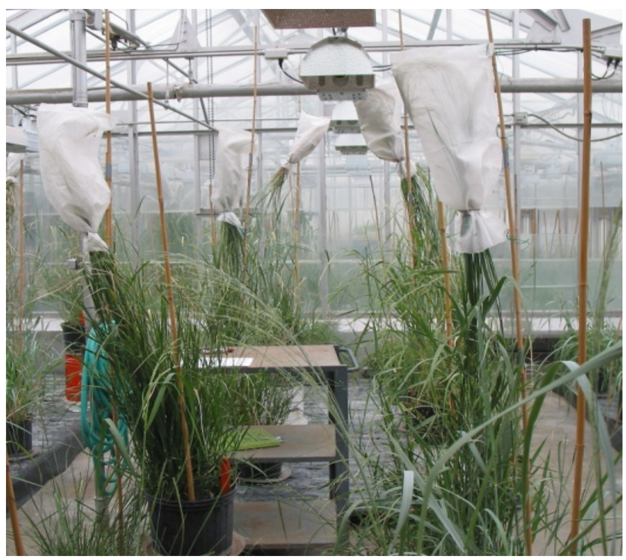

Figure 1. Switchgrass Crossing

- **New Switchgrass Crossing Procedure**

- ✓ A new switchgrass crossing procedure was developed and evaluated for improving seed yield from matings of individual plants in the greenhouse (Ken Vogel, ARS-Lincoln). The crossing in the greenhouse involved bagging panicles of plants from two different populations that were flowering at the same time. The panicles were bagged using bags made of polyester material that had mesh openings of 40 microns. Switchgrass pollen has a diameter of 45 to 50 microns. Because switchgrass is self-incompatible, the crosses can be made without emasculation. Greenhouse day length has to be manipulated for plants with maturity differences to synchronize flowering. The micro-fiber bags resulted in much higher seed set than paper pollination bags used previously. Micro-fiber bags were made at the Lincoln with purchased fabric using textile glues.

Bioenergy Switchgrass Release

- Liberty currently in release process
- Progeny of hybrid Kanlow x Summer plants were random mated and selected for winter survival, high yield & low stem lignin

Mead, NE	Tons/acre
Liberty	8.1
Shawnee	5.6
DeKalb, IL	Tons/acre
Liberty	7.3
Shawnee	5.7

Figure 2. Liberty Switchgrass in release process. Yield data summarized over three production years from multi-location trials

- **Breeding for Biomass Yield in Switchgrass**.

  ✓ **Integrated Project Impact**

  Seed of the experimental strain that is now being released as Liberty was used to establish the systems plots in Objective 2. *Sustainable Feedstock Production Systems* studies in 2012.

2. **Planned Activities**

- **Breeding and Genetics – ARS-Lincoln, Nebraska** (Ken Vogel)
  - ✓ Complete greenhouse crosses, clean and process seed from crosses.
  - ✓ Complete grinding of 2012 biomass samples. Complete 75% of NIRS scans. Complete NIRS prediction of samples from selection nurseries scheduled for completion in 2013.
  - ✓ Summarize first biomass mineral analysis study comparing methods and laboratories.
  - ✓ Complete early spring work on field nurseries.
  - ✓ Complete planned purchase of new NIRS unit and have laboratory technicians trained in its use.
- **Breeding and Genetics – ARS-Madison, Wisconsin** (Mike Casler**)**
  - ✓ Complete establishment of 40K seedlings of switchgrass and big bluestem in greenhouse.
  - ✓ Submit switchgrass manuscript on 20 years of breeding for increased biomass yield.
  - ✓ Submit first set of parental genotypes to Joint Genome Institute for sequencing. Conduct fertilization, weed control, and soil sampling on all field studies in Wisconsin.
- **Compositional Analyses – ARS-Peoria, Illinois** (Bruce Dien)
  - ✓ Finalize protocol for compositional analysis of neutral and acidic carbohydrates and Klason lignin and validate with calibration set.
  - ✓ Initiate analyses of lowland switchgrass sample set (CenUSA Set 1) differing in lignin and ash.
- **Pyrolysis – ARS-Wyndmoor, Pennsylvania** (Akwasi Boateng)
  - ✓ Complete and submit for publication a manuscript on pyrolysis products from upland switchgrass genotypes differing in stem lignin concentration.
  - ✓ Initiate py-GC/MS analyses of lowland switchgrass sample set (CenUSA Set 1) differing in lignin and ash concentration.
- **Entomology - University Nebraska-Lincoln** (Tiffany Heng-Moss)

- ✓ Collaborate with Drs. Vogel, Mitchell and Casler to develop insect sampling plans for Year 2.
- ✓ Begin sampling nurseries for insects and other arthropods in late May 2013.

- **Plant Pathology – University Nebraska- Lincoln** (Gary Yuen)

  - ✓ Determine presence of satellite PMV (SPMV) in samples from PMV-infected switchgrass plants.
  - ✓ SPMV is a separate virus species that can infect plants only in conjunction with PMV. Research with other plant species indicated that co-infection of the two viruses results in severe stunting.
  - ✓ Coordinate with other project personnel a survey of multistate field experiments for diseases.
  - ✓ Analyze virus severity data collected from breeding nurseries to identify genotypes exhibiting lowest and highest levels of virus symptoms.
  - ✓ Continue efforts in pathogenicity testing of organisms isolated from switchgrass (i.e. organisms referenced above in accomplishments 2 and 3.

3. **Actual Accomplishments (Planned Activities)**

- **Breeding and Genetics – Lincoln, Nebraska** (Ken Vogel)

  All planned activities completed and milestones were met. Specific accomplishments are listed below.

  - ✓ Fifty-eight reciprocal paired plant crosses were made in the greenhouse between plants of two lowland tetraploid populations and plants of a tetraploid upland population. A new crossing procedure was used (see "Significant Accomplishment Summary"). Six population sets of full sib families were produced. Seed was cleaned, treated to break dormancy, and planted in the greenhouse for transplanting in a field evaluation and selection nursery in late spring of 2013. Parent cultivars were included as checks.

    The purpose of the field study is to determine the following:

    - Extent if any of mid-parent and greater parent heterosis for biomass yields for the full-sib progeny in comparison to their parent population.
    - Genetic variation among progeny within and between full sib family sets for

biomass yield and other traits.

- Potential improvement in biomass yield between parent source cultivars and the populations developed from them by breeding including the hybrid progeny for biomass yield.
- Serve as a selection nursery to identify the best hybrid full-sib families for within and among family selection to produce synthetic populations. Identify superior parent plants based on their progeny performance.

✓ Two addition switchgrass selection nurseries were established in the greenhouse for transplanting into field selection nurseries in the spring.

✓ Biomass samples from 2012 were processed as scheduled.

✓ Mineral analysis work was completed for the first mineral analyses study which was designed to evaluate laboratory precision and instrumentation. A data analysis is in progress.

✓ A new NIRS unit is currently in the USDA purchasing process.

✓ The new switchgrass cultivar 'Liberty' that is in the release process has been approved by the University of Nebraska Variety Release Committee and is currently in the USDA-ARS approval process. Arrangements have been made to have a 10-acre Foundation seed field established under irrigation by the University of Nebraska Foundation Seed Division (Husker Genetics) in late spring of 2013 using breeder seed provided by ARS-Lincoln.

✓ All early spring fieldwork was completed on all field nurseries as scheduled.

- **Breeding and Genetics - Madison, Wisconsin** (Mike Casler**)**

  All planned activities completed and milestones were met. Specific accomplishments are listed below.

✓ Three journal papers were completed. One has been accepted and two are in journal review. See significant accomplishments section.

✓ Transplanted 40,000 switchgrass and big bluestem seedlings into 10 new selection nurseries at either Arlington or Hancock, Wisconsin field sites.

✓ Collected survivorship data on SWAG1, SWAG2, and SWAG3 genomic selection nurseries.

- ✓ Finished scanning the remainder of 2012 biomass samples using NIRS.
- ✓ Selected a new set of 40 diverse switchgrass samples for wet-laboratory analysis to expand and update NIRS calibrations. Samples were submitted to Bruce Dien and Akwasi Boateng for analysis

- **Entomology - University Nebraska-Lincoln** (Tiffany Heng-Moss)

All planned activities completed and milestones were met. Specific accomplishments are listed below.

- ✓ Pitfall traps and stick boards were installed in switchgrass, big bluestem and Indiangrass nurseries at Nebraska and Wisconsin.
- ✓ All sampling data from year 1 have been summarized.
- ✓ We continue to conduct greenhouse screenings to evaluate selected switchgrass, big bluestem, and indiangrass cultivars and experimental strains for their susceptibility to greenbugs and sugarcane aphids.

- **Plant Pathology – University Nebraska-Lincoln** (Gary Yuen)

All planned activities completed and milestones were met. Specific accomplishments are listed below.

- ✓ Determined the presence of satellite PMV (SPMV) in samples from PMV-infected switchgrass plants. Approximately 30% of switchgrass sample collected in 2012 that contained PMV were found to also contain SPMV. Therefore, co-infection by PMV and SPMV, which had not been reported previously in switchgrass, was shown to occur at significant frequencies, which could account the high numbers of virus stunted plant observed in 2012.
- ✓ Coordinated with other project personnel a survey of multistate field experiments for diseases. Arrangements are being made but not finalized.
- ✓ Analyzed virus severity data collected from breeding nurseries to identify genotypes exhibiting lowest and highest levels of virus symptoms. Initial statistical analysis has revealed significant differences between half-sib families in regards to virus disease severity levels in 2012. From the results, genotypes were identified for greenhouse experiments to be conducted this fall.
- ✓ Continued efforts in pathogenicity testing of organisms isolated from switchgrass (i.e. organisms referenced above in accomplishments 2 and 3. Switchgrass clonal plant material was obtained from Noble Foundation and is being propagated for

pathogenicity tests. The purpose of using vegatatively-propagated material for such test is to eliminate genetic variability in seeded plants that could complicate testing of potential pathogens.

- **Compositional Analyses – ARS-Peoria, Illinois** (Bruce Dien)

  All planned activities completed and milestones met. Specific accomplishments are listed below.

  ✓ Protocol for compositional analysis of neutral and acidic carbohydrates and Klason lignin was validated with the five-sample switchgrass calibration set. The results were compared with prior results and confirmed to be similar (Table 1) and were included in a publication (see publications list). These compositional results were used to demonstrate that Kanlow switchgrass had similar or better conversion quality for sugars and ethanol yields than Cave-in-Rock switchgrass even though Cave-in-Rock has higher forage quality than Kanlow. This result is especially significant because Kanlow has higher biomass yields. The work also demonstrated that dilute ammonium pretreatment is effective for biochemical conversion of switchgrass to sugars and biofuels.

Table 1. Composition for switchgrass samples calibration set (g/kg, dry basis)

Cultivar Lignin	**Harvest Maturity Carbohydrates**	**Glucan[1]**	**Xylan**	**Arabinan**	**Acetate**	**Total Klasson**
Native Biomass Composition						
MPV1[3]	**pre-boot**	317.1 ± 0.7[2]	223.7 ± 0.05	33.6 ± 0.1	128.8 ± 1.9	579.3
MPV2	**anthesis**	361.1 ± 2.8	218.8 ± 1.8	35.1 ± 2.1	141.6 ± 1.7	612.5
MPV3	**post-frost**	354.5 ± 2.8	237.9 ± 0.6	39.9 ± 0.1	167.4 ± 11.0	626.6
MPV4	**anthesis**	363.1 ± 3.4	238.7 ± 0.1	45.9 ± 0.4	160.3 ± 4.43	631.5
MPV5	**post-frost**	385.0 ± 7.3	245.6 ± 0.6	49.1 ± 03	165.0 ± 24.5	660.3

[1]Glucans include starch. Starch contents for MPV1 – 5 were 3.47, 61.50, 2.00, 2.55, and 1.78 g/kg, respectively.
[2]standard deviation of duplicate samples
[3]MPV1 – MPV3 are Cave in Rock upland ecotype variety and MPV4 and MPV5 are Kanlow N1 lowland ecotype variety

- **Pyrolysis – ARS- Wyndmoor, Pennsylvania** (Akwasi Boateng)

  ✓ A manuscript on the relationships between genetic differences in switchgrass stem lignin concentration and pyrolysis yields has been written and is in revision. Co-author is Gautam Sarath, ARS-Lincoln.

- ✓ A set of 54 switchgrass samples was received from ARS-Lincoln that represents families that differ in biomass lignin and ash concentration. Elemental analysis, water content, and ash content were determined. Averages and standard deviations are presented in Table 2.

Table 2. Ultimate analysis of first 54 switchgrass samples, CHNO on dry and ash-free basis

	% water (wt)	% ash (wt)	% C (wt)	% H (wt)	% N (wt)	% O (wt)
Average	6.187	4.498	49.878	5.541	0.623	43.958
Standard Deviation	0.217	0.478	0.816	0.305	0.099	0.978

- ✓ Began py-GCMS runs on switchgrass samples. Ran similarity searches for 15 most prominent peaks in GC curve, found in all samples, based on mass spectrometer data (Table 3).

Table 3. Most prominent peaks in GC curve and similarity search results, first 54 samples

Peak #	Most common MS Similarity Search Result	**Avg. Retention Time (min)**	**Avg. Peak Area**	**Avg. % of area under curve**
1	'Acetic acid'	6.25	1.45E+07	0.89%
2	'2-Propanone, 1-hydroxy-' (Acetol)	7.03	7.74E+06	0.47%
3	'Acetic acid, methyl ester'	10.31	2.74E+06	0.17%
4	'Propylene oxide'	11.87	1.88E+06	0.12%
5	'Propanoic acid, 2-oxo-, methyl ester' (Pyruvic acid, methyl ester)	12.09	1.62E+06	0.10%
6	'Furfural'	12.52	2.19E+06	0.13%
7	'Cyclohexanone'	17.71	2.87E+06	0.18%
8	2-Cyclopenten-1-one, 2-hydroxy-3-methyl-'	22.43	1.96E+06	0.12%
9	'Phenol'	24.42	1.19E+06	0.07%
10	'Phenol, 2-methoxy-' (Guaiacol)	24.62	1.89E+06	0.12%
11	Unidentified*	29.40	2.24E+06	0.14%
12	'4-Hydroxy-3-methylacetophenone'	35.59	4.38E+06	0.27%
13	'Benzofuran, 2,3-dihydro-'	35.96	6.57E+06	0.40%
14	'Phenol, 2,6-dimethoxy-' (Syringol)	37.91	1.98E+06	0.12%
15	'.beta.-D-Glucopyranose, 1,6-anhydro-' (Levoglucosan)	50.57	2.94E+06	0.18%
Similarity searches for peak #11 did not yield any good matches, further analysis is needed				

4. **Explanation of Variances**

Laboratory Py-GCMS began to malfunction during switchgrass runs and was taken offline for repairs. Statistical analysis cannot be performed until py-GCMS is fixed and pyrolysis yields are determined.

5. **Plans for Next Quarter:**

- **Breeding and Genetics – ARS-Lincoln, Nebraska** (Ken Vogel)
  - ✓ Establish two switchgrass and three big bluestem polycross nurseries.
  - ✓ Establish three new field selection and genetic evaluation nurseries.
  - ✓ Complete all late spring and summer field cultural practice work.
  - ✓ Complete stand counts and winter survival ratings on all nurseries.
  - ✓ Collect data on flowering time and plant height of plants in specific nurseries.
  - ✓ Complete statistical analyses of Biomass Mineral Analysis Study 1.
  - ✓ Complete initial summary of data from first set of comprehensive composition and pyrolysis analyses for set of switchgrass families differing in lignin and mineral concentration.
  - ✓ Develop additional sets of switchgrass, big bluestem, and indiangrass samples for composition and NIRS analyses.
  - ✓ Complete NIRS purchase and set up.
- **Breeding and Genetics – ARS-Madison, Wisconsin** (Mike Casler)
  - ✓ Maintenance of switchgrass and big bluestem nurseries at two locations.
  - ✓ Maintenance and management of CenUSA cultivar trials at 3 locations, including oversight and coordination of 10 additional locations.
  - ✓ Collect data on flowering time and plant height of all plants in all nurseries.
  - ✓ Harvest plots, measure biomass yield, and collect quality samples for all nurseries and field trials.
- **Compositional Analyses – ARS-Peoria, Illinois** (Bruce Dien)

Analyze first set of switchgrass biomass samples (52 samples) and begin development of ferulic acid measurement assay.

- **Pyrolysis – ARS- Wyndmoor, Pennsylvania** (Akwasi Boateng)

  ✓ Complete manuscript on the relationships between genetic differences in switchgrass stem lignin concentration and pyrolysis yields with Gautam Sarath.

  ✓ Resolve issues with py-GCMS and continue experiments as described with switchgrass pyrolysis sample set 1. Compare results with composition data. Initiate work with project geneticists to determine switchgrass genetic effects on pyrolysis yields.

- **Entomology - University Nebraska- Lincoln** (Tiffany Heng-Moss)

  ✓ A total of 160 pitfall and sticky board traps will be collected every two weeks from May to September in Nebraska and Wisconsin.

  ✓ Process samples from sampling Year 2 to identify potential pests and beneficial arthropods and characterize their seasonal abundance.

  ✓ Continue to screen selected switchgrass, big bluestem, and indiangrass cultivars and experimental strains for their susceptibility to greenbugs and sugarcane aphids.

- **Plant Pathology – University Nebraska- Lincoln** (G. Yuen)

  ✓ Re-evaluate switchgrass selection nurseries (PV1103, PV1104 and PV910-2102) for the second growing season for virus and fungal leaf disease severity. These nurseries were evaluated in 2012.

  ✓ Resample the switchgrass genetic and yield nurseries two viruses, Panicum mosaic virus (PMV) and satellite PVM (SPMV).

  ✓ Monitor additional perennial grass and research trials for diseases including CenUSA yield and systems analyses trials at the University of Nebraska's Agricultural Research and Demonstration Center (ARDC) near Mead, Nebraska.

6. Publications / Presentations/Proposals Submitted

- Dien, Bruce S., O'Bryan, Patricia J., Hector, Ronald E., Iten, Loren B. & Robert B. Mitchell, Qureshi, Nasib, Sarath, Gautum, Vogel, Kenneth P. & Michael A. Cotta. (2013). *Conversion of switchgrass to ethanol using dilute ammonium hydroxide pretreatment: influence of ecotype and harvest maturity. Environmental Technology* (Accepted).

- Price, David L., and Michael D. Casler. (2013). Predictive relationships between plant morphological traits and biomass yield in switchgrass. Crop Sci. (in press).

- Sarath, Gautum, Hammer, N. Sasthoff, A., Mullen, C., Boateng, Akwasi, Mitchell, Robert B., Vogel, Kenneth P., & Sattler, S. (2013, April 29 - May 2). Switchgrass, cell walls and pyrolysis. 35th Symposium on Biotechnology for Fuels and Chemicals (Abstract, oral presentation), Portland, OR.

- Stewart, Catherine L, Yuen, Gary Y., Vogel, Kenneth P., Pyle Jesse D. &. Scholthof, Karen-Beth G. (2013, August). Panicum mosaic virus - a potential threat to biofuel switchgrass production. Abstract accepted for the 2013 Annual Meeting of the American Phytopathological Society, Austin, TX.

Objective 2. Sustainable Feedstock Production Systems

The Sustainable Feedstock Production Systems objective focuses on conducting comparative analyses of the productivity potential and the environmental impacts of the most promising perennial grass bioenergy crops and management systems using a network of 14 fields strategically located across the Central United States. The overarching goal is to produce a quantitative assessment of the net energy balance of candidate systems and to optimize perennial feedstock production and ecosystem services on marginally productive cropland while maintaining food production on prime land.

1. Planned Activities

Much of the research planned for this quarter dealt with sample processing and planning for the next quarter. Nearly all planned research for this first quarter was completed on schedule.

2. Actual Accomplishments

Iowa State University

- **Armstrong System Plots**. Switchgrass plots were reseeded (6.4 lbs-seed/ac) and sprayed (8 oz. Paramount, 32 oz. Roundup/ac) to control weeds. These are the plots which did not establish well during the 2012 drought. The control plots were planted to corn.

  Frequency of occurrence stand counts for the high diversity, low diversity and switchgrass plots were completed on May 13, 2013. At that time the switchgrass had just been re-planted and had not yet emerged. Most common weeds included: dandelion, yellow mustard, shepard’s purse, and lambsquarter. Some plots were covered with mustards; many plots had annual grasses and dicots that were just emerging.

Table 4. Frequency Stand Counts (Based on 100-square Grid)			
Planted	**Treatment**	**Dicots**	**Grass**
High D	Biochar	92.5	10.0
High D	None	96.1	10.1
Low D	Biochar	95.5	16.5
Low D	None	93.1	15.8
SG	Biochar	6.8	0.0
SG	None	4.0	0.0

Decagon 5TE sensors capable of simultaneously measuring soil moisture, temperature, and electrical conductivity were installed at four depths in each of 32 locations (two per large plot/one per split plot) in the System Analysis plots. Data loggers were also installed so that soil moisture, temperature, and electrical conductivity are now being monitored every half hour. Baseline soil analysis is continuing on schedule for the 138 1.2 M soil cores, with anticipated completion in August or September 2013.

- **Field 70/71**. The plots received spring tillage where appropriate and were planted.
- **Sorenson Farm Long-term Rotation plots**. Switchgrass, corn, soybeans, and triticale were planted in the appropriate phase of each rotation. Biochar was applied on May 13, 2013 on split plots during the first year of the corn in the 6-year rotations; corn and soybeans were planted on May 15, 2013.

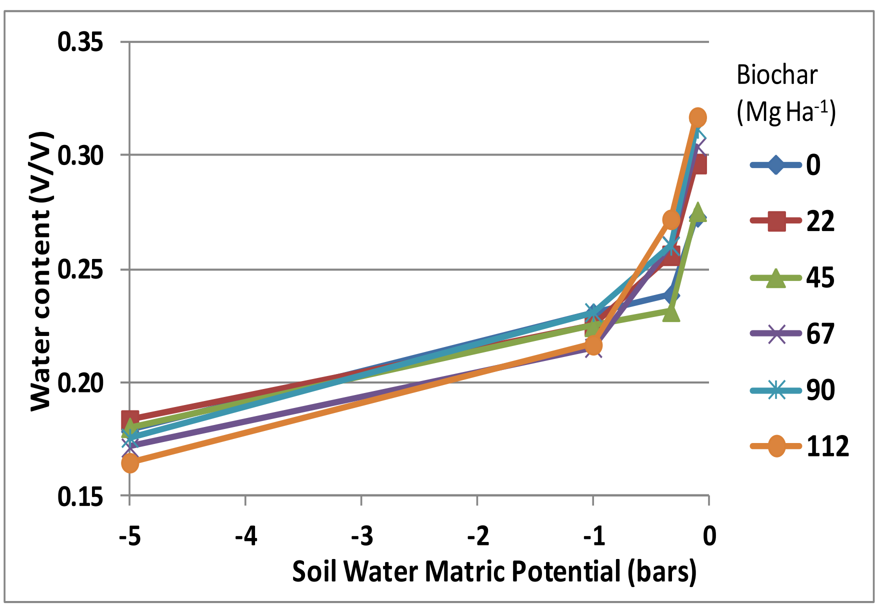

Figure 3. Ave. surface soil temperature retention curves, Boyd Farm plots receiving biochar treatment

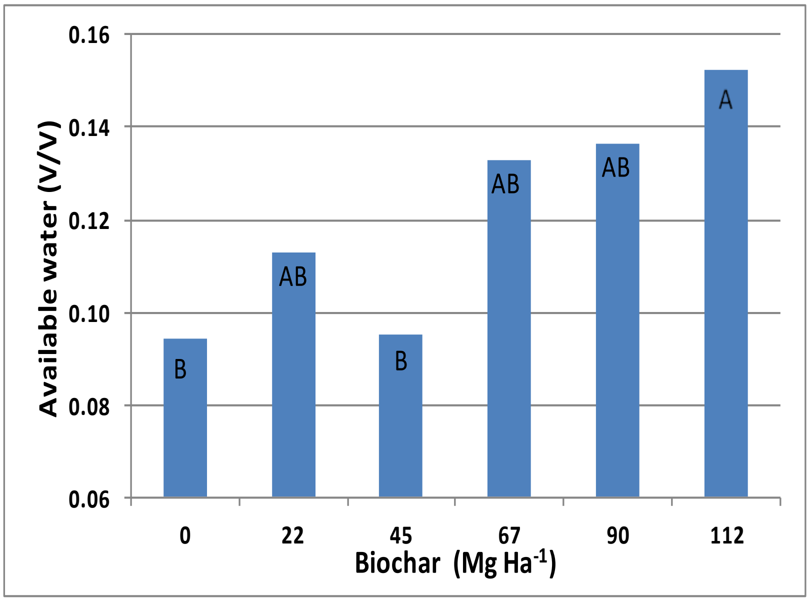

Figure 4. Impact of biochar treatments on plant available water (defined as water retained between -0.1 and -5 bars soil matric potential). Bars with different letters are significantly different at the 0.05 level.

- **Boyd Biochar Plots**.

  All plots were successfully planted to corn during the brief spell of dry weather. Base stations for monitoring greenhouse gas (GHG) emissions were installed in each plot. Soil moisture retention curves were completed. The results indicate that soils in plots receiving the high biochar application rate (112 Mg ha^{-1}) have the capacity to retain 60% more plant available water than soils in the control plots that did not receive biochar applications.

University of Illinois Urbana-Champaign

- **Illinois 2012 Factor Analysis Plots**. The plots were expected to have poor stands because of 2012 drought and weed pressure. We evaluated stand frequency in March and April 2013. Switchgrass plots had the best stands, but stand counts were still less than 5 plants m^{-2} and we decided to replant. All plots were treated with glyphosate to burn down all existing weeds before planting. The plots were reseeded using a no-till drill on May 15, 2013 and pre-emergence herbicides were applied based on recommendations from Dr. Rob Mitchell on May 16, 2013.

- **Illinois 2013 Factor Analysis Plots**. The plot area was tilled in fall 2012 and sprayed with glyphosate. Due to excessive weed pressure, glyphosate was applied twice in March and May 2013 before planting. The plots were planted using a no-till drill on May 15, 2013 and pre-emergence herbicides applied based on recommendations on May 15, 2013.

We are planning to do soil analysis for the Factor Analysis plots in 2013.

- A comparison field trial of switchgrass, big bluestem, prairie cordgrass, and Miscanthus *x* giganteus was harvested on November 15, 2012 and biomass yield data has been analyzed during this quarter (Fig. 3). The plots were transplanted in 45-cm and 90-cm spacings on wet marginal land in 2010.

  Overall, plots with 45- cm spacing produced more biomass than 90- cm spacing until 3 years after transplanting. Severe drought stress was observed in prairie cordgrass and Mxg plots during the 2012 growing season and biomass yields for prairie cordgrass and Mxg was lower than switchgrass. Kanlow switchgrass biomass yield was very high (25 Mg/ha) even under extreme drought conditions.

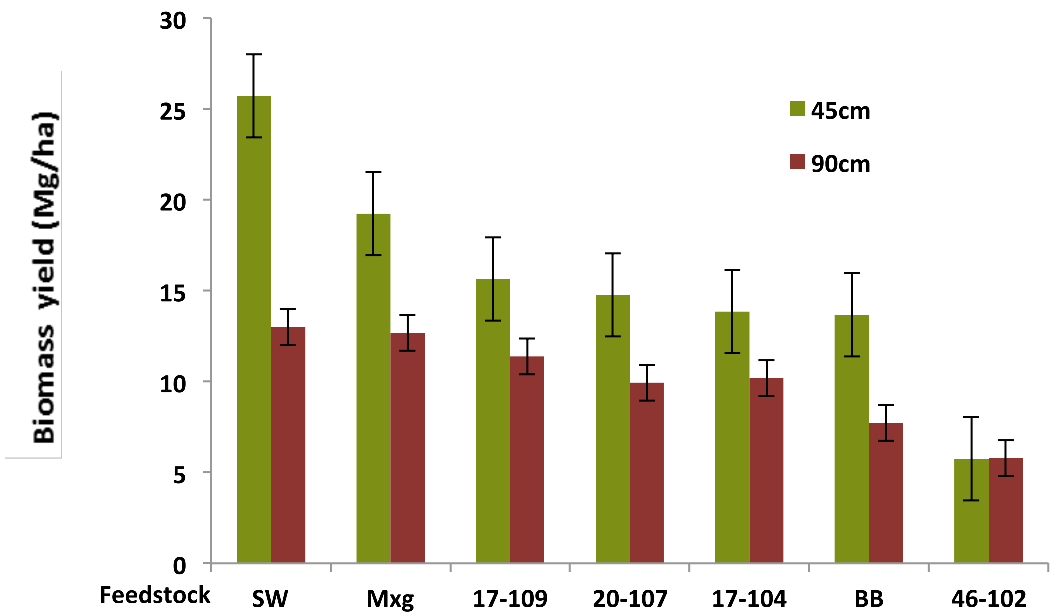

Figure 5. Biomass yield of 'Kanlow' switchgrass (SW), *Miscanthus x giganteus* (Mxg), big bluestem (BB), and four prairie cordgrass natural populations ('17-109', '20-104', '17-104', and '46-102') at 45cm and 90 cm spacing in 2012.

University of Minnesota

- Factor Analysis plots at Becker, Minnesota were harvested on October 30, 2012 using a Carter harvester (0.9 m x 4.6m). The soil at this site is a Hubbard loamy sand. Biomass was weighed wet in the field. Two subsamples (0.25m x 0.25m) were collected from each subplot, stored in plastic bags under cool conditions, dried at 60 C, and then weighed to determine dry matter content. Harvest photos and data summary results are below.

Figure 6. Biomass yield of 'Kanlow' switchgrass (SW), Miscanthus x giganteus (Mxg), big bluestem (BB), and four prairie cordgrass natural populations ('17-109', '20-104', '17-104', and '46-102') at 45cm and 90 cm spacing in 2012.

Figure 7. Carter Harvester

- In general, biomass yields were quite variable making it difficult to draw any conclusions at this point. We expect that with time, yield differences will become more distinct.

- Susan Hawkins (UVM) approached us for assistance with an article on switchgrass nutrient management to be published on eXtension.org. We delivered the finished product to Susan on April 14, 2013.

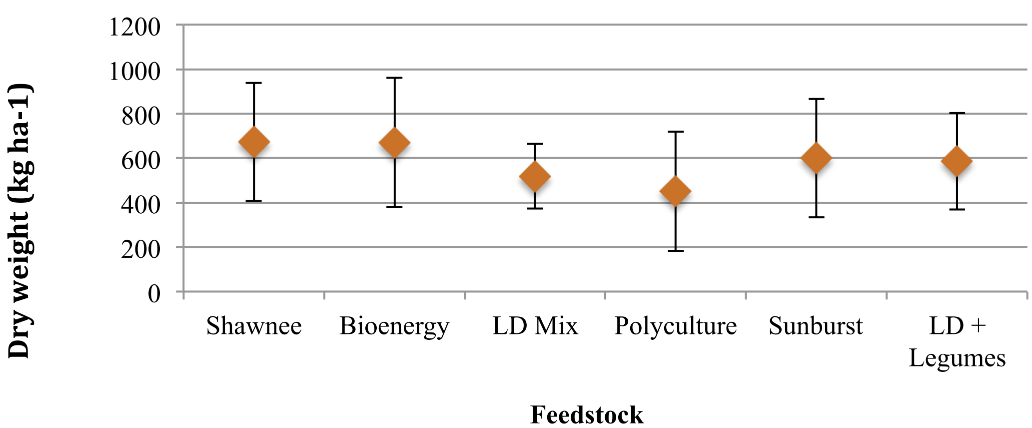

Figure 8. Calculated dry weight harvest of feedstocks (mean and std. dev.), Becker, MN, 2012

We have had a very cold spring with several large snowstorms in April followed by a prolonged wet period in May. We were able to plant the 2013 Factor Plots at Lamberton, however, on May 16, 2013.

- N application at Becker Factor plots. Due to the potential for N losses in sandy soil at Becker, we are doing a split application of N. The first application was applied on May 23, 2013. The second will be applied in early-mid June.

Purdue University

- **Throckmorton Purdue Agricultural Center Factor Analysis Plots**. Baseline greenhouse gas (GHG) emission data from a subset of the Factor Analysis Plots at the Throckmorton Purdue Agricultural Center (TPAC) were acquired. These data were averaged over weekly measurements taken April 22 to May 7, 2013 prior to field operations. Results suggest that perennial biomass production systems may produce slightly more CO_2 and low to moderate levels of CH_4 and NO_2 when compared to maize and biomass sorghum. Addition of 100 kg N/ha to maize and sorghum increases CO_2 and NO_2 emissions over the unfertilized plots.

Table. 5 Impact of biomass cropping system and nitrogen (N) rate on greenhouse gas emissions.

Biomass System	Nitrogen rate, kg/ha	CO_2, mg/h/m^2	CH_4, mg/h/m^2	NO_2, mg/h/m^2
Native Prairie	0	225	0	0.009
Switchgrass (Shawnee)	0	340	0	0.014
	100	228	0	0.003
Miscanthus	0	215	0.0005	0.004
	100	282	0	0.008
Sorghum	0	142	0	0.004
	100	182	0.005	0.013
Conventional corn	0	146	0.004	0.011
	100	162	0	0.028

✓ **Mineral Analysis - TPAC**. Mineral analyses at the TPAC Factor Analysis plots are being completed. Variable rates of N (0 to 150 kg N/ha/yr) are being applied to Shawnee switchgrass established at a site that had received annually high rates of P and K or left unfertilized (0 or 75 kg/ha P; 0 or 400 kg K/ha) for 8 years of alfalfa production that resulted in large differences in soil P and K levels (See Table 4).

Table 6. Impact of nitrogen (N), phosphorus (P), and potassium (K) fertilization on nutrient concentrations and total carbon (C) in switchgrass biomass.					
Nutrient	**Rate, kg/ha/yr**	**Tissue N, g/kg**	**Tissue P, g/kg**	**Tissue K, g/kg**	**Tissue C, g/kg**
Nitrogen	0	5.17**	0.42	1.92**	469
	50	5.50	0.41	2.01	470
	100	6.17	0.41	2.02	469
	150	6.94	0.41	2.20	470
Phosphorus	0	5.87	0.27**	2.11**	470
	75	6.02	0.56	1.96	469
Potassium	0	6.02*	0.45**	1.70**	468**
	400	5.87	0.38	2.37	471
*, ** Nutrient effect on tissue composition significant at the 5 and 1% levels of probability, respectively.					

Preliminary results of the main effects of the analysis reveal the following:

- Tissue N increased with the addition of N fertilizer but declined with high soil test K.
- High soil test P increased tissue P concentrations whereas high soil test K decreased tissue P concentrations.
- Tissue K concentrations increased with the addition of N fertilizer and with high soil test K levels, but declined with high soil test P concentrations.
- Tissue C concentrations were unaffected by N and P fertility, but increased slightly with high soil test K.
- Significant interactions among N, P, and K also were identified for some variables, but details of these results are beyond the scope of this interim report. Details will be made available upon request.

✓ **Fiber and Sugar Analysis - TPAC**. Fiber and sugar analyses at the TPAC Factor Analysis plots are being completed. Variable rates of N (0 to 150 kg N/ha/yr) are being applied to Shawnee switchgrass established at a site that had received annually high rates of P and K or left unfertilized (0 or 75 kg/ha P; 0 or 400 kg K/ha) for 8 years of alfalfa production that resulted in large differences in soil P and K levels.

Table 7. Impact of nitrogen (N), phosphorus (P), and potassium (K) fertilization on concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), ash, and soluble sugars in switchgrass biomass.						
Nutrient	**Rate, kg/ha/yr**	**NDF, g/kg**	**ADF, g/kg**	**ADL, g/kg**	**Ash, g/kg**	**Sugar, g/kg**
Nitrogen	0	717	398	66*	44	13.8
	50	718	397	68	43	13.8
	100	716	403	70	42	13.4
	150	714	394	69	42	14.0
Phosphorus	0	721*	402*	69*	42*	14.0
	75	712	395	67	44	13.5
Potassium	0	712	397	68	44*	13.7
	400	721	399	68	41	13.8
*, ** nutrient effect on tissue composition significant at the 5 and 1% levels of probability, respectively.						

Preliminary results of the main effects of the analysis reveal the following:

- Neutral detergent fiber (NDF) was not affected by N or K nutrition, but was reduced significantly with high soil test P levels.
- Trends in acid detergent fiber (ADF) mirrored those of NDF.
- Acid detergent lignin (ADL) concentrations increased with N fertility, but declined as soil test P levels increased.
- Biomass ash concentrations were unaffected by N, but increased as soil test P levels increased. In contrast, ash concentrations declined as soil test K increased.
- Biomass soluble sugars averaged approximately 13.8 g/kg and were not affected by soil test P and K, not N fertilizer application.
- Significant interactions among N, P, and K also were identified for some variables, but details of these results are beyond the scope of this interim report. Details will be made available upon request.

✓ **Mineral Analyses – TPAC Miscanthus x g Factor Analysis Plots**. Analyses at the TPAC Miscanthus x g Factor Analysis plots also are being completed. Variable rates of N (0 to 150 kg N/ha/yr) are being applied to a site that soil tests indicated differed in P and K levels. Plots were blocked and high rates of P and K (“plus” treatment: 75, 400 kg/ha, respectively) were applied or plots were left unfertilized with P and K (minus treatment). The goal is to explore the interaction between P/K fertility and N nutrition of this understudies biomass system.

Table 8. Impact of nitrogen (N), and phosphorus (P) plus potassium (K) fertilization on nutrient concentrations and total carbon (C) in *Miscanthus* biomass. The "plus" PK treatments were fertilized at 75 kg P/ha/yr and 400 kg K/ha/yr, while the "minus" PK plots were left unfertilized.

Nutrient	Rate, kg/ha/yr	Tissue N, g/kg	Tissue P, g/kg	Tissue K, g/kg	Tissue C, g/kg
Nitrogen	0	4.01**	0.45*	3.56	463
	50	4.47	0.45	4.27	461
	100	4.90	0.34	4.37	462
	150	5.26	0.36	4.28	462
P and K	Minus	4.59	0.38	3.80*	461
	Plus	4.73	0.42	4.43	463

*, ** nutrient effect on tissue composition significant at the 5 and 1% levels of probability, respectively.

Preliminary results of the main effects of the analysis reveal the following:

- Tissue N increased with the addition of N fertilizer, but there was no effect of P and K on tissue N concentrations.
- Tissue P concentrations were reduced with N fertilizer application.
- Tissue K concentrations were unaffected by N fertilizer application, but were increased with application of P and K fertilizers.
- Tissue C concentrations were unaffected by N and P/K fertility.
- Significant interactions between N and P/K also were identified for some variables, but details of these results are beyond the scope of this interim report. Details will be made available upon request.

✓ **Fiber and Sugar Analyses - TPAC *Miscanthus x g* Factor Analysis**. Fiber and sugar analyses at the TPAC *Miscanthus x g* Factor Analysis plots also are being completed. Variable rates of N (0 to 150 kg N/ha/yr) are being applied to a site that soil tests indicated differed in P and K levels. Plots were blocked and high rates of P and K ("plus" treatment: 75, 400 kg/ha, respectively) were applied or plots were left unfertilized with P and K ("minus" treatment). The goal is to explore the interaction between P/K fertility and N nutrition of this understudies biomass system.

Table 9. Impact of nitrogen (N), and phosphorus (P) plus potassium (K) fertilization on concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), ash, and soluble sugars in *Miscanthus* biomass. The "plus" PK treatments were fertilized at 75 kg P/ha/yr and 400 kg K/ha/yr, while the "minus" PK plots were left unfertilized

Nutrient	Rate, kg/ha/yr	NDF, g/kg	ADF, g/kg	ADL, g/kg	Ash, g/kg	Sugar, g/kg
Nitrogen	0	771	481	81.8	42.8	19.3
	50	771	475	81.9	44.2	18.8
	100	771	480	83.9	44.4	17.8
	150	754	469	81.9	43.9	20.8
P and K	Minus	762	480	83.5	43.4	20.2*
	Plus	771	473	81.3	44.2	18.1

*, ** nutrient effect on tissue composition significant at the 5 and 1% levels of probability, respectively.

Preliminary results of the main effects of the analysis reveal the following:

- Concentrations of neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), and biomass ash were unaffected by N or P/K nutrition.
- Biomass soluble sugars were unaffected by N, but were reduced with application of both P and K fertilizers.
- Significant interactions among N, P, and K also were identified for some variables, but details of these results are beyond the scope of this interim report. Details will be made available upon request.

USDA-ARS, Lincoln, Nebraska

- A fact sheet on establishing bioenergy demonstration sites has been authored by Rob Mitchell, Jeff Volenec, and Pam Porter is in the final stages of development.
- The 2012 Nebraska and Minnesota feedstock samples are ready for NIRS analysis.
- We made two site visits to the Iowa System Analysis plots to evaluate stands, discuss seeding and spraying protocols, and deliver seed. Management recommendations were followed.
- We distributed all seed for the project demonstration sites in Iowa, Indiana, Minnesota, and Nebraska.
- We distributed all seed for the 2013 Factor Analysis plots and for the 2012 Factor Analysis plots that needed re-seeding.

- We have scheduled an establishment field day with Dr. Kevin Shinners for the 11th or 12th of July 2013 (weather dependent) to showcase herbaceous perennial feedstock establishment.

- We have distributed frequency grids to the demonstration site coordinators.

- We burned the 2012 Nebraska Demonstration site, re-seeded thin spots in the stand, and seeded the 2013 Nebraska Demonstration site.

- We sampled the Nebraska System Analysis plots at 30-d intervals (as conditions allowed) to determine DM losses over winter. Data evaluation is in process.

- Preliminary establishment-year biomass data from the post-frost harvest in the System Analysis plots demonstrate the ability of perennial warm-season grasses to be productive, even in extreme drought.

  ✓ Switchgrass: 3.4 tons/acre

  ✓ Big bluestem: 1.2 tons/acre

  ✓ Low diversity mixture: 1.9 tons/acre

  ✓ Rainfed maize grain yield: 102 bu/acre plus 1.4 tons/acre of corn stover removed

- We completed Spring 2013 stand counts on the System and Factor Analysis plots and preliminary data indicates excellent stands following extreme drought in 2012.

- We applied fertilizer treatments to the 2012 Factor Analysis plots.

- We began sampling GHG, soil water content, and biomass at weekly intervals in the Nebraska System Analysis plots.

- We attended the Sun Grant Switchgrass Meeting to develop a national switchgrass yield map for both upland and lowland strains.

- We continue to work with the National Wildlife Federation to develop best management guidelines for perennial grasses for bioenergy.

- We shipped switchgrass bales to Iowa State University for distribution to industry partners.

3. Explanation of Variance

There were no variances – we accomplished all that we had planned during this period.

4. **Publications, Presentations, and Proposals Submitted**

   None submitted.

Objective 3. Feedstock Logistics

The Feedstock Logistics objective focuses on developing systems and strategies to enable sustainable and economic harvests, transportation and storage of feedstocks that meet agribusiness needs. The team also investigates novel harvest and transport systems and evaluates harvest and supply chain costs as well as technologies for efficient deconstruction and drying of feedstocks.

University of Wisconsin

1. **Planned Activities**

   Planned research activities included:

   - Analysis of data collected in 2012;
   - Management of the bale storage study;
   - Development of machine configurations to combine cutting/intensive conditioning/tedding;
   - Collection of post-storage size-reduction energy requirements of bales, and
   - Establishment of native grass fields for demonstration and research use.

2. **Actual Accomplishments**

   Bales were placed into storage in the fall of 2012 to investigate means to reduce DM losses from dry bales stored outdoors. Four treatments were considered in this dry bale study, including indoor and outdoor storage and bales wrapped in plastic film (either individually or in a tube). The bales have been monitored during the spring to ensure the study is progressing as planned. Bales will be removed from storage in early summer 2013.

   In 2012, we determined that both intensive conditioning and wide-swath drying enhance the drying rate of switchgrass. We have begun development of a machine configuration to combine cutting, intensive conditioning, and tedding into a single operation. This system will involve a front-mounted mower on a tractor which will also tow an intensive conditioner equipped with a mounted tedder. We have arranged for the loan of a tractor and mower to accomplish the first operations and have now acquired an intensive conditioner and tedder.

The re-configured intensive conditioner/tedder is now capable of completing three operations –cutting, intensive conditioning and wide-swath tedding in a single-pass, eliminating two field operations. Initial functional tests will be conducted using alfalfa and grasses in the summer before harvesting our perennial grasses in the fall.

We continue to quantify the energy required to size-reduce perennial grasses post-storage. Our work during the spring of 2013 involved quantification of energy required to chop overwintered switchgrass using a self-propelled forage harvester. We will begin work on quantifying energy required to size-reduce grass bales in the early summer of 2013.

Finally, we have rented 32 acres of marginal land in which we will establish a variety of perennial grasses. Rob Mitchell, Objective 2 CoPd, has provided valuable input on the type and variety of grasses. The fields have been planted in mixtures of switchgrass, big bluestem, and indiangrass. A grass establishment outreach field day is planned for early July.

3. Explanation of Variance

There were no variances – we accomplished all that we had planned during this period.

4. Plans for Next Quarter

We plan to:

- Finish analyzing our 2012 data and continuing the preparation of manuscripts for the American Society of Agricultural and Biological Engineers meeting;
- Complete our bale storage study;
- Conduct the initial evaluation of the combined cutting/intensive conditioning/tedding machine;
- Collect post-storage size-reduction energy requirements of bales removed from storage; and
- Continue establishment of perennial grasses on rented acreage and conduct an outreach field day.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Iowa State University

All activities remain on task for completion as specified in the Plan of Work.

Objective 4. System Performance Metrics, Data Collection, Modeling, Analysis and Tools

This objective provides detailed analyses of feedstock production options and an accompanying set of spatial models to enhance the ability of policymakers, farmers, and the bioenergy industry to make informed decisions about which bioenergy feedstocks to grow, where to produce them, what environmental impacts they will have, and how biomass production systems are likely to respond to and contribute to climate change or other environmental shifts.

We focus on four overarching tasks:

- **Task 1**. Adapt existing biophysical models to best represent data generated from field trials and other data sources;
- **Task 2**. Adapt existing economic land-use models to best represent cropping system production costs and returns;
- **Task 3**. Integrate physical and economic models to create spatially explicit simulation models representing a wide variety of biomass production options;
- **Task 4**. Evaluate the life cycle environmental consequences of various bioenergy landscapes.

Iowa State University

1. Planned Activities

The first two broad tasks under Objective 4 are to adapt existing biophysical models to best represent field trials and other data and to adapt existing economic land-use models to best represent cropping system production costs and returns.

2. Actual Accomplishments

We received a final acceptance for a paper that studies that the potential for cellulosic feedstocks to reduce the frequency and magnitude of flood events in the Raccoon River Watershed in Iowa (Schilling et al.) where we use a watershed based hydrologic model to represent changes in water movement under different land uses in the watershed. First, we develop a baseline scenario of flood risk based on the current land use and typical weather patterns. We then simulate the effects of varying levels of increased perennials on the landscape under the same weather patterns and compare the change in stream flows and water quality to the baseline scenario.

We continue work on a project entitled “Optimal placement of Second Generation Biofuels in a Watershed: Is Marginal Land the Answer?” for presentation at the annual meeting of the Agricultural and Applied Economics Association. This paper will address concern about how competition between corn used for ethanol production and corn used for feed has led to the suggestion that second generation feed stocks, such as switchgrass and other perennial grasses, be restricted to low productivity "marginal" land to avoid food price effects of biofuel production. Although perennial grasses have promising environmental attributes related to GHG emissions, soil erosion, and water quality, the technology to cost effectively convert them to liquid fuels is still under development. Further, these feedstocks are bulky and there are likely to be large agglomeration economies by locating fields near each other. From an environmental perspective, the optimal location of switchgrass will likely depend on the typography of fields in a watershed, proximity to waterways and soil characteristics. We present a simple model of agricultural land use to study the efficiency tradeoffs associated with restricting switchgrass to marginal land vs. allowing it to be located where it would be most profitable or achieve the greatest water quality benefits. We consider these tradeoffs explicitly for the Raccoon River watershed.

A major component of the ISU-CARD modeling work in this objective involves the improvement of SWAT models for the Upper Mississippi River Basin and the Ohio Tennessee River Basin with USGS 12-digit subwatersheds. There is now a much denser subwatershed delineation; e.g., 5,279 12-digit subwatersheds versus 131 8-digit subwatersheds for the UMRB. This modeling structure will provide the ability to perform enhanced scenarios including greatly refined targeting scenarios to study placement of switchgrass and other biofuel crops in the landscape to evaluate to evaluate the water quality and carbon effects at the landscape level. Initial calibrations of the model are complete. We have moved into a phase of in-depth testing of the Upper Mississippi River Basin (UMRB) and Ohio-Tennessee River Basin (OTRB) SWAT models. At present, the focus is on using automatic calibration via the SWAT-CUP software (http://www.eawag.ch/forschung/siam/software/swat/index) using simpler model structures which are delineated with the 12-digit subwatersheds but with no HRUs (for descriptions of 12-digit and other standard watershed classifications see http://pubs.usgs.gov/tm/tm11a3/).

3. Explanation of Variance

No variance has been experienced.

4. Plans for Next Quarter

Continue work on the first two tasks: 1) to adapt existing biophysical models to best represent field trials and other data and 2) to adapt existing economic land-use models to best represent cropping system production costs and returns. We hope to have a draft of a paper studying the optimal placement of switchgrass with respect to both bioenergy and water quality goals completed by the summer.

5. Publications, Presentations, and Proposals Submitted

- Gonzalez-Ramirez, Jimena, Valcu, Adriana & Catherine. Kling. (2012). An Overview of Carbon Offsets from Agriculture. Annual Review of Resource Economics 4 (2012) 145-160.
- Kling, Catherine. National Science Foundation. *Climate and Human Dynamics as Amplifiers of Natural Change: A Framework for Vulnerability Assessment and Mitigation Planning*. Principal Investigator, 2012-2016, $480,000.
- Kling, Catherine L., Gassman, Philip W., Schilling, Keith E., Wolter, Calvin F., Jha, Manoj K. &. Campbell, Todd D. The Potential for Agricultural Land Use Changes in the Raccoon River Basin to Reduce Flood Risk: A Policy Brief for the Iowa Flood Center. Available at http://www.card.iastate.edu/environment/presentations.aspx.
- Schilling, Keith E., Gassman, Philip W., Kling, Catherine L., Campbell, Todd, Jha, Manoj, K., Wolter, Calvin F. & Arnold, Jeffrey G. (2013, June 8). The Potential for Agricultural Land Use Change to Reduce Flood Risk in a Large Watershed. Hydrological Processes (2013). Available at http://onlinelibrary.wiley.com/doi/10.1002/hyp.9865/abstract online. DOI: 10.1002/hyp.9865

University of Minnesota

1. **Planned Activities**

   Planned activities for this quarter include continued work on Task 1 (Adapt existing biophysical models to best represent data generated from field trials and other data sources) and Task 2 (Adapt existing economic land-use models to best represent cropping system production costs and returns), and Task 3 (Integrate physical and economic models to create spatially-explicit simulation models representing a wide variety of biomass production options).

2. **Actual Accomplishments**

   We are continuing our analysis of switchgrass and corn trial yields in our investigation of yield gaps. We have expanded this analysis to consider other perennial crops. We are nearing completion of our revisions on our manuscript comparing U.S. federal agency bioenergy feedstock production scenarios for achieving Renewable Fuel Standard (RFS2) biofuel volumes. As in last quarter, we are continuing to compile production cost and return data for switchgrass, explore different biodiversity models for use in our InVEST modeling, and write scripts to automate the modeling of biomass production placement on the landscape.

3. **Explanation of Variance.**

No variance has been experienced.

4. **Plans for Next Quarter**

   Next quarter will include continued work on Tasks 1, 2, and 3, as well as continued work on Task 4 (Evaluate the life cycle environmental consequences of various bioenergy landscapes).

5. **Publications, Presentations, and Proposals Submitted**

   Objective 4 CoPd Jason Hill has submitted a proposal to USDA/NIFA: “A6101: Enhancing agriculture’s ecosystem services through sustainable bioenergy production.” We anticipate the funding decision will be made in early summer 2013.

Post-Harvest

Objective 5. Feedstock Conversion and Refining: Thermo-chemical Conversion of Biomass to Bio-fuels

The Feedstock Conversion and Refining Objective is performing a detailed economic analysis of the performance of a refinery based on pyrolytic processing of biomass into liquid fuels and will provide biochar to other CenUSA researchers. The team concentrates on two primary goals:

- Estimating energy efficiency, GHG emissions, capital costs, and operating costs of the proposed biomass-to-biofuels conversion system using technoeconomic analysis;
- Preparing and characterizing Biochar for agronomics evaluations.

Sub-objective 1. Perform Technoeconomic Analysis

1. **Planned Activities**.

   Start the development of the catalytic pyrolysis process model. Develop an experimental plan to test mild catalytic pyrolysis.

2. **Actual Accomplishments**.

   The fast pyrolysis and catalytic pyrolysis process models in Chemcad have been updated and finalized. Initial experiments testing mild catalytic pyrolysis have commenced. Initial tests are utilizing commercially available zeolite catalysts on both standard and Tandem Frontier Micropyrolysis units.

3. **Explanation of Variance**.

No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**.

   Continue with experiments to provide inputs to process model; monitor data from the Boateng group (Objective 1) and adjust model assumptions and inputs as needed.

5. **Publications**, **Presentations, and Proposals Submitted**

   None to report this period.

Sub-objective 2. Prepare and characterize biochar

1. **Planned Activities**.

   Data analysis for Boehm titrations will be completed; work will start on a draft manuscript. Ash content/X-ray diffraction analysis of inorganic components of biochars are planned.

2. **Actual Accomplishments**.

   - Bohem titrations for four new biochars were completed using a newly developed Bohem titration procedure (Fig. 9). The latest results indicate that an integrated Bohem procedure that uses the sparge method with sodium bicarbonate, the barium method with the sodium carbonate, and the barium method with sodium hydroxide consistently give reasonable results. The new results also show that use of the cartridge method with sodium hydroxide gives unreasonably low results for three of four studied biochars. The first draft of a manuscript describing problems associated with use of the traditional Bohem titration procedure and the proposed revised procedure to characterize the concentrations of reactive functional groups on the surfaces of biochars has been prepared.

   - X-ray diffraction analysis of 12 biochar samples was completed. The results indicate the presence of various crystalline phases within biochars, including graphite, sylvite, and calcite. Shown in Figure 2 are XRD patterns for biochars prepare at 700C using Cellulose, corn stover, and alfalfa meal.

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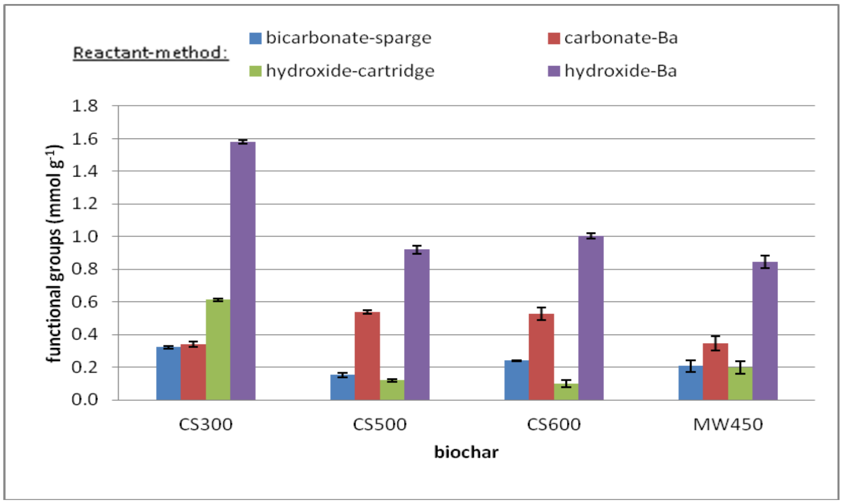

Figure 9: Bohem titrations for biochars were prepared from corn stover at 300C (CS300), 500C (CS500), 600C (CS600) and mixed wood at 450C (MW450).

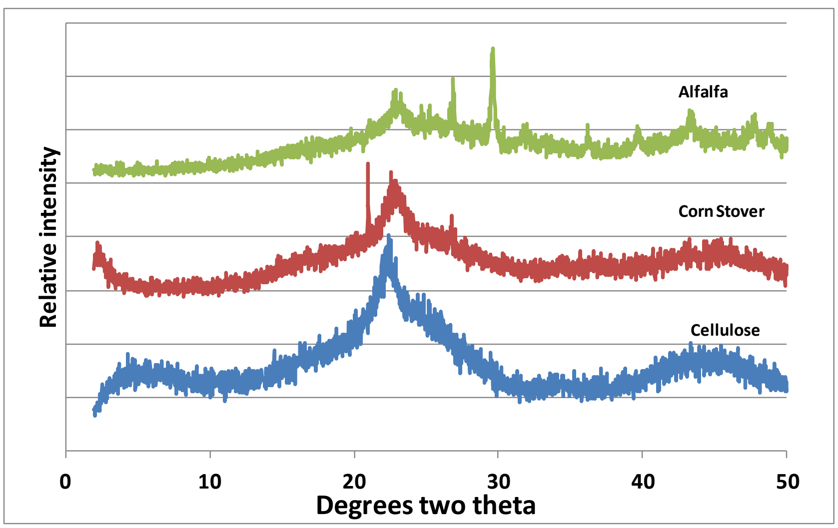

Figure 10: X-ray diffraction patterns for biochars prepared form cellulose, corn stover, and alfalfa at 700C. The results indicate that the type of feedstock influences crystalline phases found in biochars.

3. Explanation of Variance.

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter.

Complete editing and submit the Bohem titration manuscript for publication. Conduct X-ray fluorescence analysis to quantify inorganic compounds in the ash of biochars.

5. **Publications, Presentations, and Proposals Submitted**.

   None submitted.

Objective 6. Markets and Distribution

The Markets and Distribution objective recognizes that a comprehensive strategy that addresses the impacts to and requirements of markets and distribution systems will be critical to the successful implementation and commercialization of a regional biofuels system derived from perennial grasses grown on land unsuitable or marginal for the production of row crops. To create this comprehensive strategy the team focuses on two unifying approaches:

- The study and evaluation of farm level adoption decisions, exploring the effectiveness of policy, market and contract mechanisms that facilitate broad scale voluntary adoption by farmers;
- Estimate threshold returns that make feasible biomass production for biofuels.

1. **Planned Activities**

   Our team anticipated a total of four activities for the third quarter of the second year of the project.

   - Continue to push forward progress on access to farm-level CRP data (Keri Jacobs).
   - Continue development of the spatial model of biomass supply with heterogeneous producers (Richard Perrin).
   - Continue to interact with industry (Du Pont, Deere, and Stine Seeds) on a project to model the use of feedstocks as a fast pyrolysis fuel source. The business model involves a distributed system of fast pyrolysis that provides as byproducts biochar and bio-oil. Biochar will be sold as a soil amendment, and bio-oil will be sold for use in furnaces for heat. The group includes soil scientists, chemical engineers and mechanical engineers (Dermot Hayes).
   - Continue modeling and analysis efforts of the regional supply curve for grasses and stover using a real options framework (Dermot Hayes).

2. **Actual Accomplishments**

   - **Farm-level CRP data**. Little progress has been made in securing these data. We knew this was a possibility. Funding issues within the USDA and legislative language that addresses data privacy make this a difficult endeavor.
   - **Spatial model of biomass supply**. This activity is ongoing.

- **Industry Interaction - Model the use of feedstocks as a fast pyrolysis fuel source**. This activity is ongoing.

- **Modeling the regional supply curve for grasses and stover**. This activity is ongoing.

3. **Explanation of Variance**

No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**

During the fourth quarter (Year 2), our team will work on the following activities:

- Prepare for the CenUSA Intensive Program held in Ames, Iowa during June 2013.

- Prepare for the CenUSA Bioenergy Annual Meeting to be held in West Lafayette, Indiana July 30 – August 2, 2013. Our team will brief the entire CenUSA team on our Year 2 activities.

- Continue development of the spatial model of biomass supply with heterogeneous producers (Richard Perrin).

- Continue to interact with industry on an Iowa State University Bioeconomy Institute project to model the use of feedstocks as a fuel source for fast pyrolysis. The business model involves a distributed system of fast pyrolysis that provides as byproducts char and bio-oil. Char will be sold as a soil amendment, and bio-oil will be sold for use in furnaces for heat (Dermot Hayes).

- Complete modeling and analysis efforts of the regional supply curve for grasses and stover using a real options framework (Hayes). Present one of these at an international conference on this subject in late June 2013. We anticipate publishing two peer-reviewed papers in this area.

5. **Publications, Presentations, and Proposals Submitted**

- None submitted in the third quarter.

Objective 7. Health & Safety

The production of bioenergy feedstocks will have inherent differences from current agricultural processes. These differences could increase the potential for workforce injury or death if not properly understood and if effective protective counter measures are not in place.

The Health and Safety team addresses two key elements in the biofuel feedstock supply chain:

- The risks associated with producing feedstocks; and
- The risks of air/dust exposure.

1. **Task 1 – Managing Risks in Producing Feedstocks**

   a. **Planned Activities**

   The team is modifying the collection of the various tasks/responsibilities associated with producing biofeedstocks by subdividing some tasks into smaller and more specific subtasks. The major headings or grouping of tasks remains under these five areas:

   1. Establishment
   2. Maintaining
   3. Harvest
   4. On-site processing and storage
   5. Transportation

   The different risk assessment methods are being evaluated for those established tasks.

   b. **Actual Accomplishments**

   Good progress on refining the accumulated listing of tasks/responsibilities was made. Criteria for comparisons of risk assessments for handling the evaluation of the various tasks were begun and the standard risk assessment tool to use for tasks in biofeedstock production is still being constructed.

   The team strengthened the cooperative arrangement with Dennis Murphy, the investigator at Penn State University who is also working with another biofuel CAP project, to collaborate in developing a standard to assess risk in these types of tasks. The plan is to co-author some presentations and papers.

   c. **Explanation of Variance**

   None to report.

   d. **Plans for Next Quarter**

   Continued refinement of the accumulated listing of tasks/responsibilities will be accomplished. Criteria for comparisons of risk assessments for handling the evaluation of the various tasks will be made with the expected outcome of determining the standard risk assessment tool to use for tasks in biofeedstock production.

e. Publications, Presentations, and Proposals Submitted

A presentation has been submitted for the Biomass and Biofuels session of the *2013 North American Agricultural Safety Summit* hosted by the Agricultural Safety & Health Council of America. The event will be in Minneapolis, Minnesota on September 25-27, 2013.

Previous publication submitted: Schwab, C. V., and M. Hanna. 2012. Master Gardeners' safety precautions for handling, applying, and storing biochar. Cenusa bioenergy publication. ISU University Extension and Outreach, Ames, IA 50011.

2. Task 2 – Assessing Primary Dust Exposure

a. Planned Activities

The locations for dust exposures are compiled and those currently identified are being examined for determination of the most likely place to find the highest/hazardous exposure rates. This will be the selection process to determine where the pilot analysis of actual dust exposure will take place.

Appropriate monitoring equipment is still being identified for the pilot study. Approvals for human subjects and procedures have begun, but approval has not been received.

b. Actual Accomplishments

The prioritized list of locations for dust exposures is being evaluated in more detail and the primary location to be measured still remains uncertain at this time. The identification of the monitoring equipment needed to take dust samples was started but remains on hold until the exact details of the location and expected exposure are confirmed.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

Appropriate monitoring equipment will be obtained to conduct the pilot study. Approvals for human subjects and procedures will be obtained.

e. Publications, Presentations, and Proposals Submitted

None to report this period.

Outreach and Extension

Objective 8. Education

The Education Objective seeks to meet the future workforce demands of the emerging Bioeconomy through two distinct subtasks, as follow:

- To develop a shared bioenergy curriculum core for the Central Region
- To provide interdisciplinary training and engagement opportunities for undergraduate and graduate students

Subtask 1 is curriculum development. Subtask 2A is training undergraduates via an 8-week summer internship program modeled on the highly successful NSF REU (research experience for undergraduates) program. Subtask 2B is training graduate students via a 2-week summer intensive program modeled on a highly successful industry sponsored intensive program in biorenewables the team led in 2009. Subtask 2C is training graduate students via a monthly research webinar. The next portion of this report is broken into subtasks.

Subtask 1: Curriculum Development

1. **Planned Activities**

   - **Module 2. Perennial Grass Establishment and Management**

     Complete internal review and submit to Journal of Natural Resources and Life Sciences Education for peer review

   - **Module 3. Perennial Grass Harvest Management**

     Complete internal review for harvesting machinery lessons.

   - **Module 4. Storage Management**

     Continue module development activities with Amy Kohmetscher

   - **Module 5. Integrating Bioenergy Production into Current Systems**

     Complete module development activities with Amy Kohmetscher.

   - **Module 6. Balancing Energy Demand with Food, Feed and Fiber Needs**

     Complete module development activities with Amy Kohmetscher.

- **Module 7 – Overview Module (lead author John Guretzky)**

  Complete outline of the remaining content.

- **Module 8 – Ecosystems Services for Dedicated Bioenergy Crops**

  We are starting the process of outlining module content.

2. Actual Accomplishments

- Identified specific goals and developed initial evaluation tools for evaluating modules in an off-line environment (Evaluation lead: Gwen Nugent).
- Attended workshop on ADA compliance of on-line materials – will adapt new practices that improve accessibility of module activities for differently-abled students.
- Made changes to the module format for ease in publishing the content.
- **Module 1. Perennial Grass Physiology, Growth, and Development** (lead author John Guretzky) status of components:
  - ✓ Seedling emergence activity accepted for publication in *Natural Science Education*.
- **Module 2. Perennial Grass Establishment and Management** (lead author John Guretzky) status of components:
  - ✓ Initial internal review completed and edits made to the module.
  - ✓ Filmed and edited demonstration on use of frequency grid to determine perennial grass establishment success.
- **Module 3. Perennial Grass Harvest Management**. (Lead authors Pat Murphy, CenUSA CoPd and Iman Beheshti Tabar) status of components:
  - ✓ We are conducting the internal review for the mowing and conditioning lesson.
  - ✓ We have developed an additional lesson for sizing of biomass harvesting equipment.
- **Module 4. Storage Management.** (Lead authors Pat Murphy and Iman Beheshti Tabar) status of components:

  Continued module development activities with Amy Kohmetscher.

- **Module 5. Integrating Bioenergy Production into Current Systems**. **(**Lead author Nicole Olynk Widmar) status of components:

- ✓ Recording Camtasia lectures from PowerPoint slides
- ✓ Continued module development activities with Amy Kohmetscher.

- **Module 6. Balancing Energy Demand with Food, Feed and Fiber Needs** (lead author Nicole Olynk Widmar) status of components:
  - ✓ We are recording Camtasia lectures from PowerPoint slides
  - ✓ Continued module development activities with Amy Kohmetscher
- **Module 7. Introduction to Perennial Grasses as a Feedstock** (lead author John Guretzky) status of components:

  Finished conversion of webinar into lesson.
- **Module 8. Ecosystems Services for Dedicated Bioenergy Crops** (lead authors David Schlueter and Patrick Murphy)
  - ✓ Developed module content outline

3. **Explanation of Variance**

Significant changes in the format of Module 3 needed to be made for ADA compliance prior to submittal for internal and external review. These changes have been made and will not affect the schedule, plan of work or budget.

4. **Plans for Next Quarter**

- **Module 3. Perennial Grass Harvest Management**
  - ✓ Submit machinery lessons to *Journal of Natural Sciences Education* for peer review.
  - ✓ Continue module development activities with Amy Kohmetscher for harvest management and machinery sizing lessons.
- **Module 4. Storage Management**

  Continue module development activities with Amy Kohmetscher.
- **Module 5. Integrating Bioenergy Production into Current Systems**

  Continue module development activities with Amy Kohmetscher.
- **Module 6. Balancing Energy Demand with Food, Feed and Fiber Needs**

  Continue module development activities with Amy Kohmetscher.

- **Module 8: Ecosystems Services for Dedicated Bioenergy Crops**

  Begin outlining module content

5. **Publications, Presentations, and Proposals Submitted**

   None to report this period.

Subtask 2A: Training Undergraduates via Internship Program

1. **Planned Activities**

- Continue to promote the undergraduate internship program and encourage application submissions through March 15, 2013 application deadline.
- Centrally vet and rank applicants based on letter of interest, academic achievement, previous research experience and letters of recommendation.
- Pool of likely candidates given to faculty hosts for review during week of March 18, 2013 with selection decisions by March 25, 2013.
- First offers to students on March 25, 2013; second offers to students on April 1, 2013 with cohort (11 students) finalized on April 15, 2013.
- Arrange travel for accepted students.
- Secure housing for students who will be placed with faculty mentors at partner institutions.

2. **Actual Accomplishments**

- Robust promotion of the program yielded a pool of highly qualified applications by the March 22, 2013 deadline (we extended the original March 15, 2013 deadline by one week).
- Central vetting and ranking of the applications was completed on March 28, 2013.
- Pool of likely candidates given to faculty hosts for review on March 29, 2013; selection decisions provided back by April 8, 2013.
- Student phone interviews with Raj Raman took place the week of April 8, 2013.
- First offers extended in early April, second offers in mid-April, and a cohort of ten students finalized in late April 2013.

3. **Explanation of Variance**

- The original deadline of March 15 extended to March 22, 2013 to allow for submission of applications from the Nebraska Indian Community College.
- With the extension of the program from eight-weeks to ten-weeks (to ensure a full research internship experience for the student), we will have ten students in the 2013 cohort rather than 12.

4. Plans for Next Quarter

- Finalize all logistics; student travel, lodging at Iowa State and all three partner institutions (University of Minnesota, University of Nebraska, Lincoln, and Idaho National Labs), and administration of stipends.
- Provide mentor training using a 15-minute video (created by Raj Raman). We will share the link with the internship mentors (faculty/grad student/post doc) in mid-May, followed by a combined face-to-face (for ISU-based mentors) and virtual (via WebEx for partners) meeting to clarify any questions and concerns.
- Launch the program on May 28, 2013 with the arrival of the students. Run the orientation at Iowa State from May 29 – June 1, 2013; send students to appropriate lab placements for start date on June 3, 2013; schedule weekly meetings (June 5 – July 24) with student interns to discuss progress, face-to-face for ISU students and virtual (via WebEx) for partner-placement students.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Subtask 2B – Training Graduate Students via Intensive Program

1. Planned Activities

- We will compile a list of intensive program attendees.
- We will provide faculty with full program agenda and details of each objective leaders' responsibilities for their portion of the intensive program.
- We will arrange travel for graduate student participants and faculty presenters.

2. Actual Accomplishments

- We compiled list of intensive program attendees.
- We provided faculty with full program agenda and details of each objective leaders' responsibilities for their portion of the intensive program.

- We arranged travel for graduate student participants and faculty presenters.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Finalize list of intensive program attendees
- Gather final presentation titles and field experience description and details from faculty presenters
- Request final exam questions from each of the objective areas
- Finalize all logistics (travel, Iowa State accommodations for graduate student attendees and non-ISU faculty presenters, opening reception, poster session and closing awards luncheon)
- Launch the Intensive Program:

✓ **Sunday, June 9:**

Participants arrive at Iowa State in the afternoon

6:00 PM: Welcome Dinner and Overview of Program

7:00 PM – 8:00 PM: Grad Student Research Poster Session

✓ **Monday, June 10:**

9:00 AM – 11:30 AM: Objective 1 – Feedstock Development lecture by Ken Vogel

1:00 PM – 4:00 PM: field tours at the ISU Agronomy Farm led by Ken Moore and Ken Vogel

✓ **Tuesday, June 11:**

9:00 AM – 11:30 AM: Objective 2 – Field Level Sustainability lecture by Rob Mitchell

1:00 PM – 4:30 PM: Biochar field tour led by David Laird and Doug Karlen

✓ **Wednesday, June 12**

9:00 AM – 11:30 AM: Seminar – Responsible Conduct of Research by Dr. Clark Wolf, ISU Center for Bioethics

1:00 PM – 4:00 PM: Objective 3 – Feedstock Logistics lecture followed by BioCentury Research Farm tour by Stuart Birrell

- ✓ **Thursday, June 13:**

9:00 AM – 11:30 AM: Objective 5 – Feedstock Conversion/Refining lecture by Robert Brown

1:00 PM – 4:00 PM: lab experience at the Biorenewables Research Lab led by Robert Brown and staff

- ✓ **Friday, June 14:**

8:00 AM – 10:00 AM: Objective 7 – Health and Safety lecture by Mark Hanna

10:15 AM – 12:00 PM: Objective 9 – Extension and Outreach lecture/visioning exercise led by Jill Euken

1:30 PM – 3:00 PM: Industrial Advisory Board Panel Session moderated by Raj Raman

- ✓ **Saturday, June 15:**

9:00 AM – 12:00 PM: Teams of 5-8 grad students discuss challenges presented by the Industrial Advisory Board

1:00 PM – 3:00 PM: Teams report on response to challenges to Ken Moore, Raj Raman, and Patrick Murphy

- ✓ **Sunday, June 16:**

Free Day – Recreation Option – a guided Boone River canoeing trip

- ✓ **Monday, June 17:**

9:00 AM – 11:30 AM: Objective 4: System Performance lecture by Jason Hill

1:00 PM – 3:30 PM: Objective 6: Markets and Distribution lecture by Keri Jacobs

- ✓ **Tuesday, June 18:**

9:00 AM – 12:00 PM: Final Exam

12:00 – 1:00 PM: Awards Luncheon

1:00 PM: Participants depart Iowa State

5. Publications, Presentations, and Proposals Submitted

None to report this period

Subtask 2C –Subtask 2C – Training Graduate Students via Monthly Research Webinar

1. Planned Activities

- Organize the first three research webinars.
    - ✓ Objective 1 – February 22
    - ✓ Objective 2 – March 29
    - ✓ Objective 3 – April 25

2. Actual Accomplishments

- Held Objective 1. *Feedstock Development* research webinar on February 22, 2013:
    - ✓ *Twenty Years of Switchgrass Improvement to Create a Dedicated Bioenergy Crop* by Michael Casler.
    - ✓ *Genomic Selection to Improve Biomass Yield of Switchgrass* by graduate students Emily Rude and Guillaume Ramstein.
- Held Objective 2. *Sustainable Feedstock Production Systems* research webinar on March 29, 2013:
    - ✓ *Biochar mediated changes in soil quality, nutrient uptake, and maize yield in tow ongoing field trials* by Natalia Rogovska.
- Held Objective 3. *Feedstock Logistics* research webinar on April 25, 2013:
    - ✓ *Perennial grass feedstock logistics* by Kevin Shinners and Stuart Birrell.

3. Explanation of Variance

Not applicable.

4. Plans for Next Quarter

- Considering the heavy load we have with educational programming (10 undergraduate research interns, and the delivery of the graduate Intensive Program on June 9-18, we are holding off on any CenUSA research seminars until the monthly CoPd meeting scheduled for August 30, 2013.

- Since we have completed seminars on objectives 1-3, we will pick up in August with Objective 4.
- Begin organization of next three webinars (Objectives 4-6) to be delivered Aug – October 2013.

5. Publications, Presentations, and Proposals Submitted

Guretzky, John, Kohmetscher, Amy & Namuth-Covert, Deanna. (2013) Grass Seed Structure and Seedling Emergence. *Nat. Sci. Educ.* 42:1-1. doi:10.4195/nse.2012.0018w

Objective 9. Extension and Outreach

The Outreach and Extension Objective (Objective 9) serves as CenUSA's link to the larger community of agricultural and horticultural producers and the public-at-large. The team delivers science-based knowledge and informal education programs linked to CenUSA Objectives 1-7.

The following teams conduct the Outreach and Extension Objective's work:

- **Extension Staff Training/eXtension Team**

  This team concentrates on creating and delivering professional development activities for Extension educators and agricultural and horticultural industry leaders.

- **Producer Research Plots/Perennial Grass Team**

  This team covers the areas of:

  ✓ Production, harvest, storage, transportation;

  ✓ Social and community impacts;

  ✓ Producer and general public awareness of perennial crops and Biochar agriculture;

  ✓ Certified Crop Advisor training.

- **Economics and Decision Tools Team**

  The Economics and Decision Tools Team will focus on the development of crop enterprise decision support tools to analyze the economic possibilities associated with converting acreage from existing conventional crops to energy biomass feedstock crops.

- **Health and Safety Team**

This team integrates its work with the Producer Research Plots/Perennial Grass and the Public Awareness/Horticulture/eXtension 4-H and Youth teams (See Objective 7. Health and Safety).

- **Public Awareness/Horticulture/eXtension/4-H and Youth Team**

  This team focuses on two separate areas:

  ✓ **Youth Development.** The emphasis is on developing a series of experiential programs for youth that introduce the topics of biofuels production, carbon and nutrient cycling, and biochar as a soil amendment.

  ✓ **Broader Public Education/Master Gardener.** These programs acquaint the non-farm community with biofuels and biochar through a series of outreach activities using the Master Gardener volunteer model as the means of introducing the topics to the public.

- **Evaluation/Administration Team**

  This team coordinates CenUSA's extensive extension and outreach activities. The team is also charged with developing evaluation mechanisms for assessing learning and behavior change resulting from extension and outreach activities, compiling evaluation results and preparing reports, and coordination of team meetings.

1. Extension Staff Training/eXtension Team

a. Planned Activities

✓ One webinar for Extension Educators

✓ One article and one fact sheet

✓ Conference grant application

✓ Extension Energy Summit presentation

b. Actual Accomplishments

✓ Organized and held the webinar "Thermochemical Conversion of Biomass to Drop-In Biofuels" for Extension Educators, producers and industry professionals.

✓ Hosted the "Farm Energy Education Case Studies" seminar (22 participants).

✓ Taught one presentation at the Extension Energy Summit in Colorado (April 29-May 1, 2013,Colorado State University – Fort Collins, CO).

- ✓ Participated in round-table conversations with extension delegates from five of the six NIFA Bioenergy CAPS, addressing issues and successes of projects and how to work together (8 participants) at the Extension Energy Summit in Colorado.
- ✓ Completed an extension article "Setting Up A Perennial Grass Energy Crop Demonstration Plot."
- ✓ Prepared a conference grant application to AFRI for a 2014 National Bioenergy and Environment Summit for University Extension, not-profit conservation leaders and agricultural and natural resource outreach and policy professionals.

c. Explanation of Variance

We did not experience any variance from our expected plans.

d. Plans for Next Quarter.

- ✓ We will begin building CenUSA Image gallery in the eXtension website (http://farmenergymedia.extension.org). The goal for the quarter is 30 images.
- ✓ We will identify CenUSA topics for the "eXtension Ask an Expert" function and identify specialists to provide responses to incoming questions.
- ✓ We will continue planning for the 2014 Extension Energy Summit.

e. Publications, Presentations, Proposals Submitted

"Establishing and Managing Perennial Grass Energy Crop Demonstration Plots."

2. Producer Research Plots/Perennial Grass Team

a. Planned Activities

- ✓ Monitor emergence from on-farm plots established in Year 1.
- ✓ Finalize arrangements with farmers who are establishing on-farm plots in Year 2.
- ✓ Arrange for seed, fertilizer, herbicides, etc. for plots.

b. Actual Accomplishments

- ✓ **Iowa**.
    - o The spring has been wet and cold.
    - o We continued monitoring the Year 1 plot.

  - We burned about 20% of 2012 plot in early May 2013.
  - We established a second plot at Iowa State University's Southeast Demo Farm on May 21, 2013. We planted into tilled corn residue. We will spray with herbicide last part of May 2013.

- ✓ **Nebraska**.
  - We continued monitoring the Year 1 plot.
  - We burned and assessed the stand and interseeded where needed.
  - We sprayed plots with Paramount and Atrazine and applied nitrogen fertilizer according to protocol.
  - The second year site at Milford has been planted, sprayed and applied according to protocol. We will take stand counts in June 2013.

- ✓ **Indiana**.
  - A Year 2 plot will be planted late May or early June 2013 at the FFA Leadership Center.
  - We are evaluating the need to reseed the first plot in North Central Indiana.
  - A field day is planned for June 21, 2013 in cooperation with the Indiana Forage Council. The field day will include a tour of the Year 1demonstration site, stand counts, and seed drill calibration.

- ✓ **Minnesota**
  - Spring has been late and wet.
  - The Year 2 demonstration plot is ready to be seeded and will likely be seeded at the end of May 2013 or in the first part of June depending on weather.
  - Erosion and stand establishment issues at the Year 1 site may lead to limited data from that location (Note: poor stand is its own teaching tool as soil type, topography, etc. make for challenging stand establishment).

c. Explanation of Variance

We did not experience any variance from our expected plans.

d. Plans for Next Quarter

- ✓ We will continue demonstration plot establishment processes (herbicide treatments, etc.).
- ✓ We will a co-host for the June 21, 2013 *Indiana Forage Day* field day in Indiana (co-hosted by the Miami County Soil and Water Conservation District and the Indiana Forage Council, - See more at: http://www.thecropsite.com/news/13946/forage-day-to-cover-bioenergy-crop-uses#sthash.oUNFeZGG.dpuf)
- ✓ We will complete final revisions and publish "Switchgrass Weed Control"; and "Switchgrass Nutrient Management."
- ✓ We will run quarterly Google Analytics on eXtension CenUSA pages and maintain and update the index.
- ✓ We will host two webinars. The tentative topics are: entomology and plant pathology related to perennial grass production for biofuel production.
- ✓ We will gather raw footage for two videos (entomology, water quality or plant pathology).
- ✓ We will write and produce a fact sheet related to hydro-ecological and water quality benefits of perennial grasses.
- ✓ We will convert eXtension e-electronic fact sheets to PDF format.

e. Publications, Presentations, Proposals Submitted

- ✓ The eXtension Farm Energy website has published "Index: Resources from CenUSA - Sustainable Production and Distribution of Bioenergy for the Central USA" (http://www.extension.org/pages/68136).[4] Access these newly published resources through the index:
- ✓ **Fact Sheets, Guides and Articles**
    - o Switchgrass (*Panicum virgatum* L.) for Biofuel Production
    - o Switchgrass (*Panicum virgatum* L.) Stand Establishment: Key Factors for Success
    - o Logistical Challenges to Switchgrass (*Panicum virgatum* L.) as a Bioenergy Crop
    - o Test Plots Show How Perennial Grasses Can Be Grown for Biofuels
    - o How to Successfully Harvest Switchgrass Grown for Biofuel

[4] These resources are also available through other CenUSA sites such as the CenUSA website and the YouTube and Vimeo CenUSA channels.

- ✓ **Research Summaries**
  - Biochar Can Improve the Sustainability of Stover Removal for Bioenergy
  - Biofuel Quality Improved by Delaying Harvest of Perennial Grass
- ✓ **Frequently Asked Questions - FAQs**
  - Why is it important to be able to grow a consistent and uniform supply of a biomass feedstock?
  - Should I fertilize switchgrass when I plant it?
  - When should I plant switchgrass?
  - Will switchgrass grow well in my region?
  - How can I get a switchgrass crop to dry faster in the field once it's been cut?
  - How high should I cut switchgrass? I am growing it as a bioenergy crop.
  - Can I use my regular haying equipment to harvest switchgrass grown as a biofuel?
  - How can I reduce dry matter losses to a biomass crop during storage?
- ✓ **CenUSA** Video **Channels**
  - **Vimeo Channel** (https://vimeo.com/cenusabioenergy). This social media/video channel continues to have impact. During this quarter the 23 CenUSA videos archived on Vimeo have 153 Vimeo plays (without loads) and 5,666 loads. CenUSA videos were embedded on various web pages 2,881 times this quarter, meaning that people are sharing the CenUSA videos with others through their own pages. All total, 8,547 people were exposed to the CenUSA project.
  - **YouTube Channel** (www.youtube.com/user/CenusaBioenergy). There were 940 total "views" of CenUSA videos during this quarter for a total of 3140 minutes. We also gained 6 new channel subscribers for a total of 21 subscribers.

3. Economics and Decision Tools

a. Planned Activities

Build spreadsheet model to help evaluate economic and environmental impacts of switching marginal land in MN to switchgrass.

b. Actual Accomplishments

A spreadsheet model was developed and a first run was completed. The model will be available in the summer of 2013.

c. Explanation of Variance

We did not experience any variance from our expected plans.

d. Plans for Next Quarter

We will continue planning for the CenUSA/Mississippi River Basin Watershed Nutrient Taskforce joint workshop (including economics/environmental sessions), tentatively scheduled for September 23-25, 2013 in Minneapolis, Minnesota (http://water.epa.gov/type/watersheds/named/msbasin/index.cfm).

e. Publications, Presentations, Proposals Submitted

Spreadsheet model (See above).

4. Health and Safety

See Objective 7 report above.

5. Public Awareness/Horticulture/eXtension/4-H and Youth Team

a. Planned Activities – Youth Development

- ✓ Plan a 4-H science workshop.
- ✓ Develop e-learning modules for high school aged learners.
- ✓ Get biochar activities into second Indiana classroom at local middle school utilizing relationships established during the previous quarter.
- ✓ Complete youth biofuel fact sheets.

b. Actual Accomplishments – Youth Development

- ✓ Workshop planning is nearly complete and we are ready for students to arrive in June 2013.
- ✓ eModules are under development.
- ✓ Development of school based programing lessons and activities are underway.
- ✓ Youth biofuels fact sheets are with editor.

- ✓ We have hired undergraduate students to assist with various aspects of project.
- ✓ We are meeting with the state FFA Executive Director regarding establishment of the educational test plot.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

- ✓ We will complete the 4-H Science Renewable Energy Workshop.
- ✓ We will continue the expansion of the online modules and lesson plans. We will further develop the working outline for 4-H curriculum and school-based activities.
- ✓ We will finish the youth biofuels fact sheets.
- ✓ We will evaluate the data from 4-H Science Workshop.

e. Publications, Presentations, Proposals Submitted

- ✓ The youth biofuels fact sheets are with editor.
- ✓ We have submitted an abstract for presentation at National Science Teachers Association National Conference in 2014.

3.B Broader Public Education/Master Gardener Program

a. Iowa

- ✓ **Planned Activities**
  - We will hold an Adobe Connect meeting, "Biochar 101" for Muscatine County Master Gardeners on March 12, 2013 for recruitment of MG volunteers for the biochar project.
  - We will hold the "Biochar 101" presentation for the Cass County Master Gardener potluck meeting on March 26, 2103 for volunteer recruitment. We invited Bernie Havlovic of the Armstrong Research Farm to attend and report on 2012 biochar activities to the group.
  - We will present "Biochar 101" for Boone County Master Gardener meeting on April 8, 2013 to recruit volunteers.

- We will present "Biochar 101" at Story County Master Gardener meeting on April 8, 2013 to recruit volunteers.

✓ **Actual Accomplishments**

- We prepared the presentation "Biochar 101."
- We tested the Adobe Connect session with the Muscatine group two hours prior to meeting time, with everything working fine. At start of meeting, excessive feedback situation forced shutdown of the session.
- We held the "Biochar 101" presentation at the Cass County ISU Extension Office meeting on March 26, 2013 for volunteer recruitment with 32 people in attendance. Obtained a sign-up of 17 Master Gardeners interested in volunteering for the CenUSA project.
- We presented "Biochar 101" at the Boone County ISU Extension Office on April 8, 2013 with 8 potential volunteers attending. Three Master Gardeners volunteered to help with the CenUSA project.
- We presented "Biochar 101 at the Story County ISU Extension Office in Nevada, with approximately 40 people attending on April 14, 2013. Fifteen Master Gardeners signed up to help with the CenUSA biochar gardens.
- We planted test plot seeds and took photos.
- We transplanted seedlings to six packs.
- We had a telephone meeting with CenUSA Youth Horticulture team on April 1, 2013.

✓ **Explanation of Variance**

- The Muscatine, Iowa Adobe Connect meeting was not held as scheduled due to excessive audio feedback and high pitched squealing that could not be corrected.

✓ **Plans for Next Quarter**

- We will hold meeting with Minnesota CenUSA team to discuss planting, data collection and reporting.
- We will sort test plot plants for shipping to the three Iowa sites.
- We will plant test plots at the three Iowa location with Master Gardener assistance.

- We will hold follow-up trainings at each test site to instruct Master Gardeners in proper data collection and reporting expectations.
- We will develop reporting methods for data collection.
- We will obtain volunteer t-shirt and glove sizes and distribute to each group.

b. Minnesota

✓ **Planned Activities**

- We will order seeds for biochar garden sites; contract with grower to start some of the seeds early.
- We will recruit volunteers for biochar garden sites in Minnesota.
- We will update applications, position descriptions and procedures for volunteers.
- We will participate in CenUSA Extension Staff Training team phone meeting on April 1, 2013 to review upcoming activities.
- We will participate in the Anoka County Extension Master Gardeners Home Landscaping and Garden Fair event on April 13, 2013. A non-staffed biochar exhibit will be put on display.
- Kurt Spokas will develop a webinar explaining what biochar is and where it comes from for the purpose of training volunteers.
- We will order more biochar from Royal Oak for the new site.

✓ **Actual Accomplishments**

- We ordered seeds for the biochar garden sites and contracted with grower to start some of the seeds early.
- We recruited 35 volunteers for the CenUSA biochar garden sites in the Twin Cities metro and another 22 volunteers and staff for the Fond du Lac site.
- We updated volunteer applications, position descriptions and procedures.
- We held Extension Team meeting on April 2013 to review upcoming activities.
- We set up a CenUSA Biochar Horticulture exhibit at the Anoka County Extension Master Gardeners Home Landscaping and Garden Fair and provided a sign-up sheet so visitors could obtain additional information. Five people requested

additional information. The CenUSA Master Gardener Annual Report and the CenUSA website were sent within one week of the event.

- Kurt Spokas developed a webinar explaining what biochar is and how it is produced for the purpose of training volunteers in late May 2013.
- We arranged for another 450 lbs. of biochar to be shipped from Royal Oak (Royal Oak donated the biochar; project covered the cost of shipping).

✓ **Explanation of Variance**

No variance has been experienced and accomplishments are on schedule.

✓ **Plans for Next Quarter**

- We will hold a meeting with the Iowa CenUSA Master Gardener team in Clear Lake Iowa on May 6, 2013.
- We will hold a local Extension Master Gardener site leader meeting on May 15, 2013.
- We will plant three metro gardens during the week of May 20, 2013.
- We will apply biochar to the new Fond du Lac Reservation site in late May or early June 2013.
- Plant new Fond du Lac Reservation site in early June 2013.
- Conduct soil tests for each site.
- Prepare biochar exhibits for local county fairs and events and the 2013 Minnesota State Fair.
- Blog about progress at the gardens.
- Attend the CenUSA Annual meeting in Indiana in July.
- Participate in the Extension team phone meeting on June 3rd.
- Collect data on select plants in the gardens May, June, and July.

✓ **Broader Public Education/Master Gardener Program - Publications, Presentations, Proposals Submitted**

- eXtension blog about the CenUSA Biochar Gardens.

- Draft Kurt Spokas presentation on "Biochar: What is it?"
- Updated Master Gardener volunteer position description and application.
- Updated Master Gardener volunteer tool "Data Collection Instructions and 2013 Harvest Dates: CenUSA Biochar Project.
- "Biochar Utilization 101" presentation.

6. Evaluation and Administration

a. Planned Activities

- ✓ We will follow up with industry contacts who attended the December 2012 CenUSA workshop to finalize details regarding quantity and processing they want for the biomass samples.
- ✓ We will secure CenUSA perennial grasses and corn stover for industry collaborators from CenUSA Breeding and Agronomy teams.
- ✓ We will make arrangements to process the CenUSA biomass to ship to CenUSA industry collaborators.
- ✓ We will assist all CenUSA Extension staff members with developing, administering and tabulating evaluations.
- ✓ We will prepare grant application to submit to USDA NIFA conference grant.
- ✓ We will meet with Iowa Secretary of Agriculture and Land Stewardship Bill Northey to discuss a potential joint workshop between CenUSA and the Mississippi River Basin Watershed Nutrient Task Force.
- ✓ We will form a planning committee to develop the between CenUSA and the Mississippi River Basin Watershed Nutrient Task Force and plan and conduct meetings for the committee.

b. Actual Accomplishments

- ✓ We provided material to ADM.
- ✓ We secured and arranged for grinding of CenUSA biomass for shipment to KiOR.
- ✓ We secured and arranged for grinding of CenUSA biomass for shipment to Renmatix.
- ✓ We prepared and submitted grant application to USDA NIFA for an Extension Renewable Energy Summit in 2014.

- ✓ We participated in meeting of CAP Extension teams.
- ✓ We met with Secretary Northey to discuss the potential joint workshop between CenUSA and the Mississippi River Basin Watershed Nutrient Task Force.
- ✓ We formed a CenUSA - Mississippi River Basin Watershed Nutrient Task Force joint meeting planning committee meetings and held three meetings for the joint workshop.
- ✓ We finalized locations for the Joint Workshop and signed contracts with hotel for meeting rooms and hotel rooms.

c. Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter:

- ✓ We will continue meeting with and supporting Extension CenUSA teams.
- ✓ We will recruit industry collaborators to attend CenUSA Annual meeting.
- ✓ We will continue planning for the CenUSA and Mississippi River Basin Watershed Nutrient Task Force joint workshop.

e. Publications, Presentations, Proposals Submitted

A grant application to USDA-NIFA for 2014 Extension Renewable Energy Summit.

"Our vision is to create a regional system for producing advanced transportation fuels derived from perennial grasses grown on land that is either unsuitable or marginal for row crop production. In addition to producing advanced biofuels, the proposed system will improve the sustainability of existing cropping systems by reducing agricultural runoff of nutrients and soil and increasing carbon sequestration."

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