cenusa bioenergy

Quarterly Progress Report

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

October 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: August 1, 2013 – October 31, 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.

Featured First Quarter Activities

- **2013 CenUSA Annual Meeting**.[1] The 2013 CenUSA Annual Meeting was held July 30 – August 2, 2013 at Purdue University. Jeff Volenec, co-project director of the CenUSA *Sustainable Feedstock Production Systems* objective, hosted the meeting. (See Exhibit 1. *2013 Annual Meeting Agenda*).

  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)

[1] We discuss the Annual Meeting in this first quarter report because the meeting dates straddle the 4th quarter of Project Year 2 and the first quarter of Project year 1.

CAP project located at the Louisiana State University AgCenter.[2] The breakdown of attendees is shown in Table 1 and in Exhibit 2. *Annual Meeting Participant List*.

Table 1. 2013 CenUSA Annual Meeting Attendance	
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:

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

A full description of the field tour activities is provided in Exhibit 3. *CenUSA Annual Meeting Field Tour Agenda*.

A new meeting feature was the poster session and reception featuring the nine CenUSA undergraduate 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.

Meeting participants completed a meeting evaluation that will be used in planning the 2013 annual meeting (See Exhibit 4. *2013 Annual Meeting Evaluation*).

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

- **Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops**
  CenUSA and the Mississippi River Basin Watershed Nutrient Taskforce (http://water.epa.gov/type/watersheds/named/msbasin/index.cfm) hosted the joint workshop *Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops* in Minneapolis, Minnesota, September 23-25, 2013. (See Exhibit 5. *Workshop Agenda and Exhibit 6 Workshop Report*) Co-Pd Jason Hill (System Performance Metrics, Data Collection, Modeling Analysis, and Tools Objective) who worked with Jill Euken (CoPd, Extension and Outreach) to lead this effort. This meeting was a direct outcome from discussions that took place at the CenUSA Bioenergy mid –year meeting that took place immediately following the 2012 CenUSA Commercialization Workshop. Participants included:

  - ✓ Ann Bartuska, USDA Deputy Undersecretary for Research, Education and Economics
  - ✓ Nancy Stoner, Acting Assistant Administrator for the Office of Water (EPA)
  - ✓ Bill Northey, Iowa Secretary of Agriculture and Co-Chair, Hypoxia Task Force
  - ✓ David Miller, Iowa Farm Bureau Director of Research and Commodity Services

- **Smarter Agriculture / Purpose & Agenda Dialogue on Critical Data for Agriculture**

  CenUSA COO Anne Kinzel attended this meeting, held in Potomac, Maryland October 10-11, 2013. CenUSA Co-Pd Jeff Volenec and CenUSA collaborator Slyvie Brodeur hosted the meeting. The workshop objective was to "coalesce the grass-roots efforts currently on-going across a broad array of projects and entities and to foster the dialogue on critical steps in the pathway from our present situation of short data lifecycles with limited return on investment to a data."

- ***New Crops: Bioenergy, Biomaterials, and Sustainability (Host: Association for the Advancement of Industrial Crops (AAIC)* Annual Meeting, October 13-16, 2013, Washington DC**

  Ken Moore, Robert Brown, Jason Hill, Jill Euken, Anne Kinzel, Val Evans and Sorrel Brown attended the meeting on behalf of CenUSA. While the meeting was somewhat truncated due to the government shutdown, Ken Moore, Robert Brown, Jill Euken and Sorrel Brown were able to make presentations to NIFA Coordinated Agriculture Program colleagues and AAIC members.

▪ **CenUSA Bioenergy Advisory Board**

The Advisory Board turnout for the 2013 Annual Meeting was excellent. Board members continued their pattern of involvement by questioning the CenUSA team during the annual meeting, a process that serves as valuable feedback and advice to the CenUSA team. The board member comments are provided in Exhibit 8. *CenUSA Advisory Board Comments Project Progress: August 2012-July 2013*.

Advisory Board members have been attending the monthly research seminars, a practice which we will encourage in year 3.

- **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 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 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]

  - **Connections with other the AFRI-CAP Program.** CenUSA COO Anne Kinzel attended the annual meetings of the *System for Advanced Hardwood Biofuels in the Pacific Northwest (AHB-PNW)* held in Corvallis, Oregon (September 9-11, 2013) and the *Southeast Partnership for Integrated Biomass Supply Systems* held in Raleigh, North Carolina (September 24-26, 2013).

  - **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. Our website (http://www.cenusa.iastate.edu) has been upgraded and continues to provide an excellent public presence for the project.

  - **Financial Matters.** The Administrative Team continues to monitor all project budgets and subcontracts to ensure adherence to all sponsor budgeting rules and requirements.

[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.

- **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

- *Uromyces graminicola* was found to cause rust in the CenUSA Bioenergy switchgrass yield trial in Nebraska. This finding is significant in that the fungus is not known to occur or reported to be important as a rust pathogen in other states. Switchgrass entries varied in rust resistance from 'resistant' to 'moderately susceptible.'

- RT-PCR methods for *Panicum mosaic virus (PMV*) and the satellite of PMV (SPMV) were verified to be effective in detecting the viruses in switchgrass field samples. These new methods provide sensitive and virus-specific ways to identify infection by PMV alone or in combination with SPMV.

2. Planned Activities

- **Breeding and Genetics – ARS-Lincoln, Nebraska** (Rob Mitchell)

  ✓ 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 40 biomass samples supplied by Mike Casler.
  - ✓ Complete development of protocols for measuring hydroxycinnamic acids and hexane extractables.
- **Pyrolysis – ARS-Wyndmoor, Pennsylvania** (Akwasi Boateng)
  - ✓ Perform py-GC/MS experiments on larger set of samples of various switchgrass.
  - ✓ Continue writing manuscript with Gautam Sarath on relationships between germplasm properties and product yields.
  - ✓ 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)
  - ✓ Pitfall and sticky board traps will continue to be collected every two weeks until the end of September.
  - ✓ 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** (Gary Yuen)
  - ✓ Continue monitoring switchgrass entries in CenUSA yield trial located at ARDC (Mead) Nebraska, for diseases.

- ✓ Analyze switch field samples collected in 4th quarter of Year 2 (May-July 2013) for presence of *Panicum mosaic* virus.

3. **Actual Accomplishments (Planned Activities)**

- **Breeding and Genetics – Lincoln, Nebraska** (Rob Mitchell)
  - ✓ Plant height data and other phenotypic data were collected on switchgrass selection nurseries. Data collection on one nursery was delayed by the federal government shutdown in October 2013.
  - ✓ Seed was harvested on all polycross nurseries and seed increase nurseries as planned. Seed was harvested on the Foundation seed field of Liberty switchgrass.
  - ✓ Biomass harvests were initiated on some nurseries in late October 2013 after a killing frost.
  - ✓ Work on the compiling the composition and pyrolysis data from the CenUSA Set 1 biomass samples was delayed due to the government shut down in October 2013.
  - ✓ Two manuscripts were submitted to a journal. See below: *Publications/ Presentations/Proposals Submitted.*
- **Breeding and Genetics - Madison, Wisconsin** (Mike Casler**)**
  - ✓ All three locations of switchgrass, big bluestem, and indiangrass variety trials were harvested after killing frost. Biomass samples were collected.
  - ✓ SWAG1 and SWAG2 selection nurseries were harvested and sampled.
- **Compositional Analyses – ARS-Peoria, Illinois** (Bruce Dien)
  - ✓ Samples supplied by Mike Casler have been analyzed for soluble sugars, starch, structural carbohydrates and uronic acids, and acid soluble and insoluble lignins.
  - ✓ We have completed method development for measuring hexane extractable material (e.g. lipids, waxes, etc.).
  - ✓ We have completed method development for measuring ester lined hydroxycinnamic acids is completed. We have nearly completed method development for ether linked hydroxycinamic acids.
- **Pyrolysis – ARS-Wyndmoor, Pennsylvania** (Akwasi Boateng)

- ✓ The manuscript has been partially written but not completed, a draft results section is complete.
- ✓ Could not find significant correlations between biomass composition and pyrolysis product concentrations due to the random variation in pyrolysis product concentrations.

- **Entomology - University Nebraska-Lincoln** (Tiffany Heng-Moss)
  - ✓ Tiffany Heng-Moss and her staff initiated sampling to identify and monitor potential arthropod pests and natural enemies associated with switchgrass and other bioenergy grasses. Samples were collected every two weeks from May through September 2013 using pitfall traps and yellow sticky traps from switchgrass, big bluestem, and Indiangrass nurseries in Nebraska and Wisconsin. Samples are being processed to identify potential pests and beneficial arthropods and characterize their seasonal abundance.
  - ✓ Greenhouse screening evaluations are still underway to evaluate selected switchgrass, big bluestem, and Indiangrass cultivars and experimental strains for their susceptibility to sugarcane aphids.

- **Plant Pathology – University Nebraska-Lincoln** (Gary Yuen)
  - ✓ In July 2013, leaves were collected from 23 switchgrass plots in the CenUSA yield trial in Nebraska that exhibited symptoms indicative of virus infection. The samples were tested during this quarter for the presence of *Panicum mosaic* virus (PMV) using the ELISA method. Low-level positive results were obtained in 34% of the samples. Because of the low magnitude of the ELISA reactions, samples will have to be retested by RT-PCR to verify the presence of PMV.
  - ✓ Beginning in August 2013, switchgrass entries in the CenUSA yield trial were observed to have rust disease. Switchgrass entries were rated for rust severity using a 0 (no symptoms) to 9 (highest severity) scale described by Gustafson et al., 2003. Considerable differences among entries were found, with mean rust ratings ranging from 1 (resistant) to over 5 (moderately susceptible). Infections were found to be caused by two rust genera, Uromyces and *Puccinia*, on the basis of teliospore morphology. The relative frequency of infection by the two genera varied considerably from plant to plant with some plants being infected solely by one genus or the other while other plants were infected with both genera. The Uromyces is presumed to be *U. graminicola*. Identity of the *Puccinia* species is unknown.

- ✓ Leaves from randomly selected switchgrass plants were collected from three genetic studies at ARDC and tested for the presence of *Panicum mosaic* virus (PMV) using the ELISA method. The incidence of PMV infection in two of the experiments planted with half-sib families exceeded 50% and 72%. In the third trial planted with 125 genotypes from each of 5 switchgrass strains, incidences of PMV detection ranged from <10% in Kanlow and strains derived from Kanlow to >70% in Summer.
- ✓ RT-PCR methods using primers specific for PMV and the satellite of PMV (SPMV) were verified to be effective in detecting the viruses in switchgrass field samples.

4. Explanation of Variances

- Akwasi Boateng's ARS-Wyndmoor Pyrolysis team is collaborating with Gautam Sarath on a manuscript on the relationships between germplasm properties and product yields. The manuscript has not yet been completed due to other involvements of both parties.
- No new data was generated due to the departure of the summer 2013 interns. New py-GC/MS is being set up and Dr. Michelle Serapiglia will arrive from Cornell mid-November 2013 to continue analysis.

5. Plans for Next Quarter:

- **Breeding and Genetics – ARS-Lincoln, Nebraska** (Rob Mitchell)
  - ✓ Complete after-frost biomass harvests on switchgrass, big bluestem, and indiangrass yield tests.
  - ✓ Complete after-frost harvests on switchgrass, big bluestem, and indiangrass selection nurseries.
  - ✓ Yield and agronomic data entered into databases.
  - ✓ Seed cleaning work on harvested seed initiated and 50% completed.
  - ✓ Biomass grinding work initiated and 50% completed.
  - ✓ New NIRS Unit installed and calibrated.
  - ✓ Ash and mineral composition analysis work completed on two experiments.
- **Breeding and Genetics – ARS-Madison, Wisconsin** (Mike Casler**)**
  - ✓ Grinding and scanning on NIRS of approximately 5000 biomass samples.

- ✓ Planning a new set of multi-location variety trials to evaluate the next set of elite switchgrass and big bluestem selections.

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

  - ✓ Complete analysis of 52 and 40 samples, supplied by CenUSA Co-Project Directors Ken Vogel and Michael Casler, respectively, for hexane extractable material.

  - ✓ Begin to analyze above samples for hydroxycinnamic acids.

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

  - ✓ Continue writing manuscript with Gautam Sarath as described above.

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

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

  - ✓ Continue processing 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 sugarcane aphids.

- **Plant Pathology – University Nebraska- Lincoln** (G. Yuen)

  - ✓ Continue analysis of samples from the three genetic study fields at ARDC for SPMV. The occurrence of PMV and PMV+SPMV will be compared with the occurrence of virus symptoms to determine the relationship between virus infection and symptom expression.

  - ✓ Continue assay of leaf samples from switchgrass in CenUSA yield trials for the presence of viruses.

  - ✓ Analyze seed from PMV- and PMV+SPMV-infected switchgrass by RT-PCR to determine if seed can harbor these viruses.

  - ✓ Initiate greenhouse experiments to evaluate the resistance of four switchgrass strains to infection by PMV and PMV+SPMV. Procedures to be completed next quarter include planting of switchgrass seeds, hand inoculation of plants with PMV or the PMV+SPMV combination, and verification of virus status in the developing plants.

  - ✓ Identify the *Puccinia* species causing rust in CenUSA switchgrass yield trial using morphometric and molecular techniques.

6. Publications / Presentations/Proposals Submitted

- Stewart, C. L. Yuen, G. Y., Vogel, K., Pyle, J. D., & Scholthof, K. B. G. (2013, August 10-14). *Panicum mosaic virus—A potential threat to biofuel switchgrass production.* Poster presented at the 2013 Annual Meeting of the American Phytopathological Society, Austin, TX.

- Stewart, C. L. Yuen, G. Y., Vogel, K., Pyle, J. D., & Scholthof, K. B. G. (2013, September 10-12). *Panicum Mosaic Virus and its Satellite Virus – Potential Risks to the Yield of Biofuel Switchgrass*. Oral presentation given at Switchgrass II, Madison, WI.

- Stewart, C. L. Yuen, G. Y., Vogel, K., Pyle, J. D., & Scholthof, K. B. G. (2013). *Panicum Mosaic Virus and its Satellite Virus – Potential Risks to the Yield of Biofuel Switchgrass.* Abstracts from Switchgrass II, p. 7. Madison, WI.

- Vogel, K.P., Sarath, G; & Mitchell, R.B. (Submitted 09/29/13). 201x. Improved pollination bags for switchgrass. *Crop Sci.*

- Vogel, K.P., Mitchell, R.B., Sarath, G. & Casler, M.D. (Submitted 9/23/13). 201x. Registration of 'Liberty' switchgrass. *J. Plant Registrations.*

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.

- **Iowa State University**

  - **2013 Research Summary for the Armstrong Plots**

    Switchgrass was replanted first week of May (6.4 lbs./acre seeding rate) following unsuccessful establishment in 2012 due to drought. Corn was planted mid-May with a preplant application of 32% liquid nitrogen at 175 lb/ acre in the first week of May. Decagon soil moisture sensors were installed at five depths in the center of each of the thirty two subplots. These sensors allow us to collect soil moisture, temperature, and EC data every 30 min at 10, 20, 50, 75, and 100 cm depths during the 2013 growing season. The soil moisture data has not yet been analyzed. Corn grain samples were collected shortly before harvest in late October. Soil samples for fertility evaluation were collected to the depth of 6 inches after the harvest. Emergence data were collected on 5/13/13 and 5/31/13 using the frequency grid method in the perennial species plots. Plants were noted as either grasses or broadleaf species. We collected data on percent ground cover of individual species periodically throughout the main part of the growing season (6/18/13, 7/2/13, and 8/7/13) as well as an end of season measurement on 10/10/13. For these measurements, we visually identified and estimated percent of cover by species within $0.25m^2$ quadrats, taking 8 measurements in each unique plot during the growing season and 4 subsamples in October. In addition to the visual cover data, stand / canopy heights were measured on 6/18/13, and leaf area index (LAI) and light transmittance were measured on 7/2/13 in all plots (including corn) (Fig. 1). Due to a large number of weedy species (foxtails, mustards, lambsquarter, pigweed, etc.), the plots were mowed to approximately 8 inches on 7/21/13.

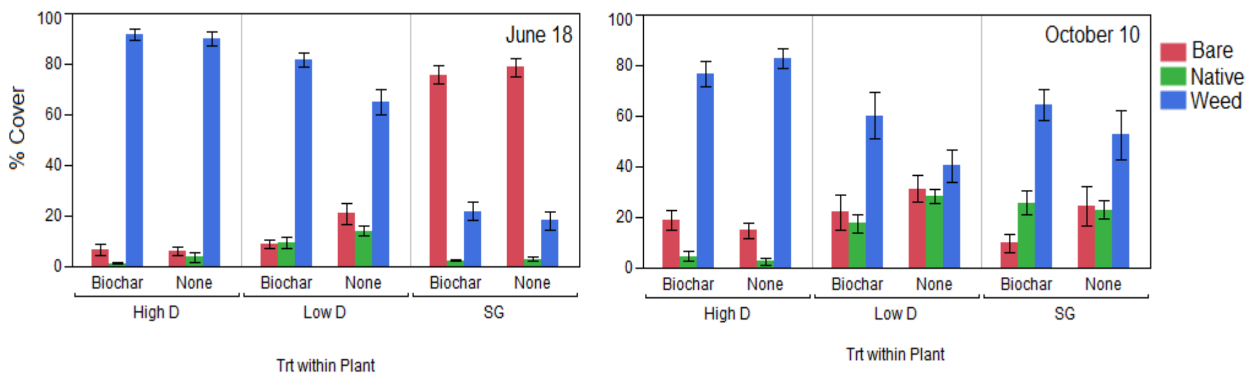


Fig 1. Influence of biochar application on percent cover of the high diversity (High D) and low diversity (Low D) native prairies, and switchgrass measured in June and October 2013.

While native cover did increase throughout the 2013 growing season, native species abundance remained lower in the high diversity plots than the low diversity and switchgrass monoculture plots (Fig. 3). There was initially a large proportion of bare ground in switchgrass monocultures, but this dropped to similar levels by October 2013. The LAI was highest and light transmittance was lowest in both diversity treatments, likely due to the higher presence of weeds (Table 2). There was also a slight tendency for greater leaf cover in plots with a biochar application.

Table 2. Impact of biomass system (Plant) and biochar application on radiation transmission through the canopy and Leaf Area Index (LAI).

	% Transmission		LAI	
Plant	**None**	**Dicots**	**Biochar**	**None**

Corn	47.3%	54.0%	1.75	1.58
High D	15.8%	27.0%	4.30	3.16
Low D	20.8%	27.5%	3.67	3.29
SG	43.0%	53.5%	1.89	1.46

- **2013 Research Summary Boyd Plots.**

  Boyd plots are assessing biochar impacts on soil quality and crop growth. Biochar was incorporated to a depth of 30 cm in the fall of 2010 at 6 application rates ranging from 0 to 50 tons/ac. Plots were planted to corn in mid-May and managed under continuous no-till corn. Corn was harvested at the end of October for estimation of grain and biomass yields. Greenhouse gases were measured throughout the growing season in the plots amended with 0, 10, 20, and 30 tons per acre of biochar. Moisture sensors were installed at two depths (15 and 45 cm) in late June 2013 and monitored for the remainder of the growing season.

  An on-going greenhouse soil column-leaching study is using soil collected from the biochar plots on the Boyd farm. The greenhouse study allows accurate quantification of bulk density, water retention, saturated hydraulic conductivity, nitrogen leaching, GHG emissions, and N-use efficiency, which can be related to field plots results.

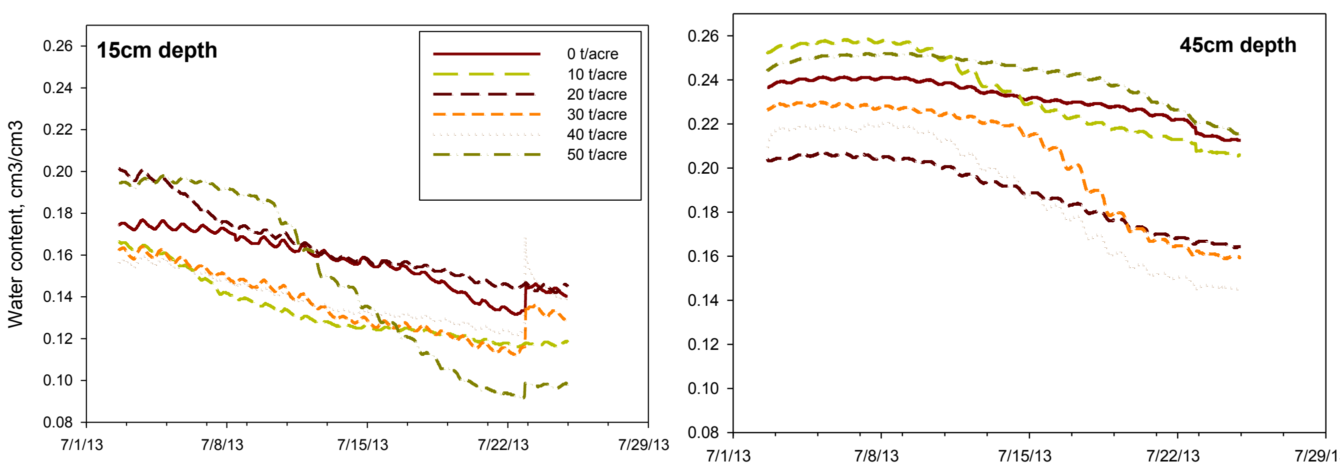


Figure 2. Temporal changes in volumetric soil moisture content at two depths as influenced by biochar application on the Boyd biochar plots. Moisture content ranged from the 19.5% (17.4% for control) observed on July 2 to 9.3% (13.2% for control) observed on July 21.

- **University of Illinois Urbana-Champaign**

- **Factor Analysis Plots**
  - ✓ 2012 Factor Analysis plots were reseeded in 2013 and new factor analysis plots were seeded in May 2013.
  - ✓ Stands were measured using a frequency grid in the Factor Analysis plots (Fig. 3). The primary data indicates all plots have more than 20 plants per square meter.
  - ✓ Plots were mowed and spot-sprayed with atrazine+paramount on June 27, 2013 to control warm-season grassy weeds.
  - ✓ Miscanthus x giganteus was transplanted in the Factor Analysis plots on June 4, 2013 and prairie cordgrass was transplanted on July 8, 2013.
  - ✓ Even though all plots have adequate stands, plots will not be harvested in 2013 due to low biomass yield associated with drought in summer and late-season weeds.
- Comparison field trial
  - ✓ Plant height data as well as light interception data were taken on a weekly basis in the comparison field trial of 'Kanlow' switchgrass (SW), IL ecotype big bluestem (BB), four populations of prairie cordgrass (20-107, 46-102, 17-109, 17-104), and Miscanthus x giganteus (Mxg) (Fig. 4).
  - ✓ Biomass harvest will be done in November.

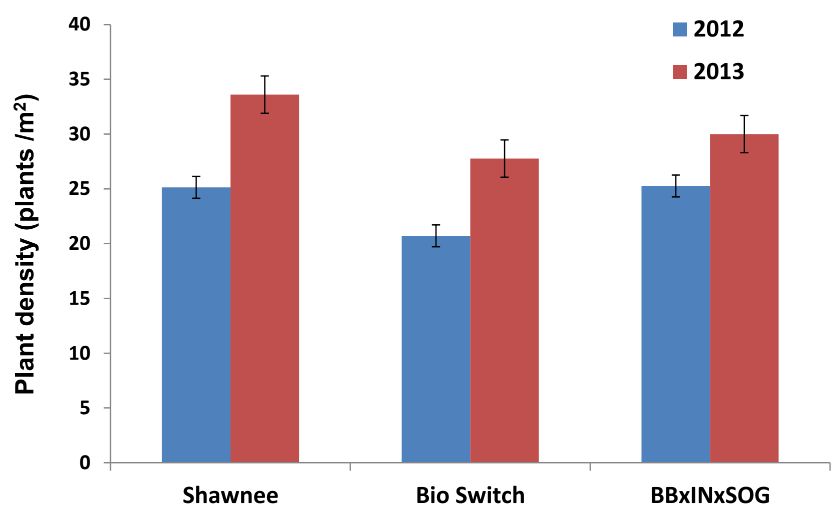
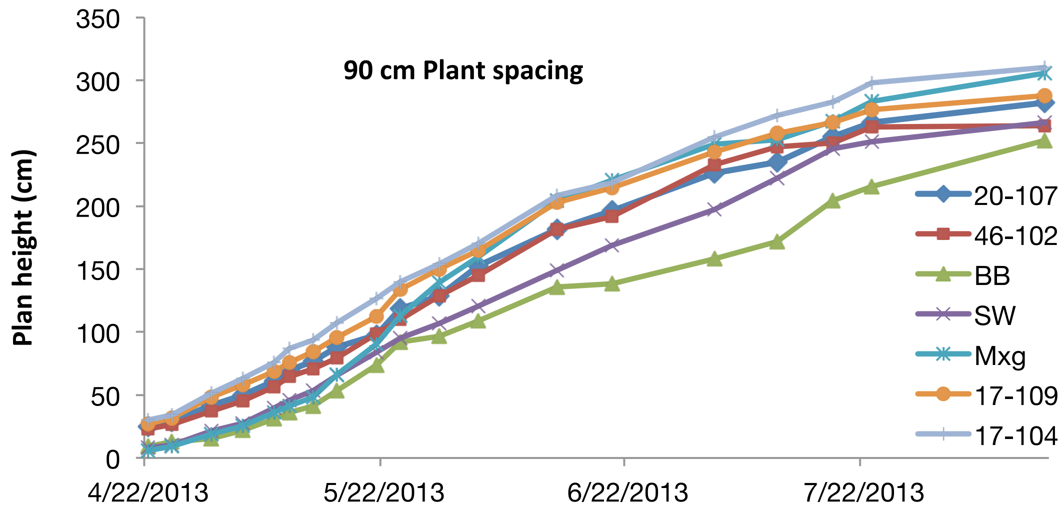


Fig. 3. Plant density measured using a frequency grid of the factor analysis plots planted in 2012 and replanted in 2013 (blue) and planted in 2013 (red).



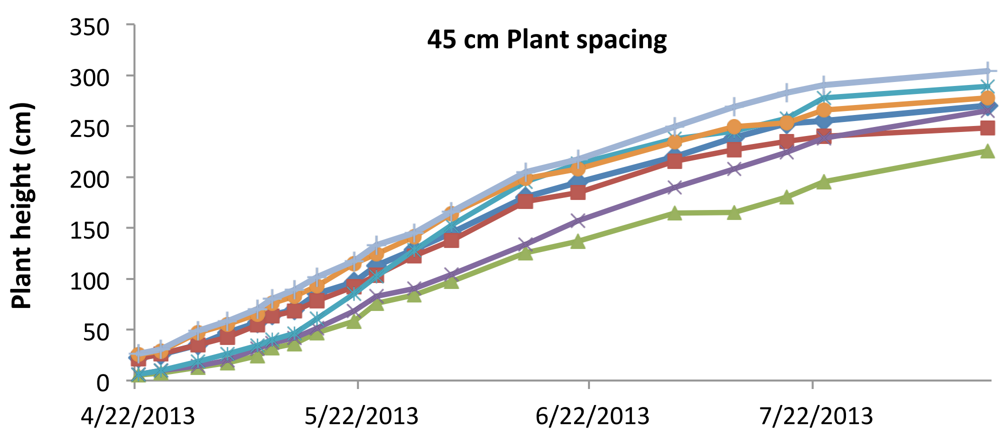


Figure 4. Plant height of 'Kanlow' switchgrass (SW), IL ecotype big bluestem (BB), four populations of prairie cordgrass (20-107, 46-102, 17-109, 17-104), and *Miscanthus x giganteus* (Mxg) during the growing season of 2013 in the comparison field trial planted in 2010.

- **University of Minnesota**

- **Factor plots at Becker, Minnesota**

  ✓ The near-anthesis harvest was completed on August 14, 2013.

  ✓ The post-frost harvest was completed on October 24, 2013. While harvest data have not yet been analyzed, biomass will likely be low due to a very dry August and early September. Between August 7 and September 14, 2013 less than 0.6" of rain was observed. The soil at Becker is excessively drained loamy sand, and the lack of moisture appeared to force much of the grass into premature dormancy. By the time we harvested in late October 2013, the grasses appeared to have very low moisture content.

- **Factor plots at Lamberton, MN**

✓ The Lamberton plots were harvested on November 12, 2013. While the data have not yet been analyzed, the switchgrass monoculture plots appeared to have good establishment year production. The low-diversity mix (LD), polyculture and low-diversity plus legumes (LD + leg) plots were less robust as a result of weed pressure, despite spraying LD plots according to protocol and hand-weeding the polyculture and LD + leg plots.

✓ Post-harvest establishment counts, while not yet compiled, indicate robust grass stands. Plots likely will not require reseeding/overseeding in the spring of 2014.

Photo 1. Harvesting factor plots at the Sand Plain Research Farm in Becker, MN (left) and the Southwest Research and Outreach Center in Lamberton, MN (right)

- **Purdue University**

- **Perennial Biomass Factorial Studies**

  ✓ **Actual Accomplishments**

Yield and biomass compositional of perennial grasses grown at the Throckmorton (TPAC) and Northeast Purdue Ag Centers (NEPAC) were analyzed (Tables 3, 4). Yield at TPAC exceeded that at NEPAC for all species and ranged from 919 kg/ha for the big bluestem/indiangrass prairie at NEPAC to 4344 kg/ha for Liberty switchgrass at TPAC. Yields were generally low at both locations due to extremely dry conditions in 2012. Re-planting the perennials at the Southeast Purdue Ag Center (SEPAC) failed in 2012 due to drought. Biomass N concentrations were generally higher for all species grown at TPAC, and Miscanthus tended to contain higher N than the other perennials. Biomass carbon concentrations were slightly lower in Miscanthus than the other perennials at both sites.

Table 3. Biomass yield and concentrations of nitrogen (N) and carbon (C) in biomass of Liberty switchgrass, a re-established big bluestem-indiangrass prairie, and *Miscanthus x giganteus* at the Throckmorton Purdue Ag Center (TPAC) and the Northeast Purdue Ag Center (NEPAC) in 2012. The results of analysis of variance and the least significant difference (LSD) between means are provided.

	Liberty Switchgrass		Big Bluestem-Indiangrass		*Miscanthus x g*		Statistics/LSD
	TPAC	NEPAC	TPAC	NEPAC	TPAC	NEPAC	
Biomass Yield, kg/ha	4344	3793	1642	919	3921	2267	Site: P<0.01 Species: 680
Biomass N, g/kg	10.3	6.7	8.5	7.2	11.6	8.5	Site: P<0.01 Species: 1.4
Biomass C, g/kg	467	474	468	467	461	463	Site: ns Species: 4.8

Fiber analyses also were completed on the perennials sampled at TPAC and NEPAC in 2012 (Table 2). Samples from NEPAC were generally higher in NDF and ADF when compared to samples from TPAC. Lignin concentrations of switchgrass were similar at both sites and relatively high, whereas lignin concentrations of Miscanthus varied with site, being low at TPAC and higher at NEPAC. Lignin concentrations were consistently low for the big bluestem/indiangrass prairie. Ash concentrations of switchgrass were low, while that of Miscanthus was relatively high compared to the other perennials. Biomass sugar concentrations were generally similar among species at these sites in 2012 with the exception of Miscanthus at TPAC where high sugar concentrations were observed.

Greenhouse gas emissions were continued on the perennial factor analysis plots, with maize included as a control (Figs. 5, 6). Unfertilized prairie plots emitted very little nitrous oxide. However, both switchgrass and Miscanthus emitted significant nitrous oxide during the three weeks following N application. N-fertilized maize also emitted considerable nitrous oxide during the 6 weeks post-application of N. emission of carbon dioxide was not influenced by N fertilization, but was higher in the perennials than maize. This is likely due to the far greater subterranean biomass in perennial systems than in annuals like maize.

Table 4. Biomass composition of Liberty switchgrass, a re-established big bluestem-indiangrass prairie, and *Miscanthus x giganteus* at the Throckmorton Purdue Ag Center (TPAC) and the Northeast Purdue Ag Center (NEPAC) in 2012. Biomass was analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), total ash, and soluble sugars. The results of analysis of variance and the least significant difference (LSD) between means are provided.

Biomass Composition Attribute	**Liberty Switchgrass**		**Big Bluestem-Indiangrass**		***Miscanthus x g***		**LSD**
	TPAC	NEPAC	TPAC	NEPAC	TPAC	NEPAC	
NDF, g/kg	676	736	647	720	662	712	Site: 18 Species: P=0.08
ADF, g/kg	362	396	355	399	345	414	Species x Site: 12
ADL, g/kg	54	53	43	43	45	56	Species x Site: 3.7
Ash, g/kg	48	34	50	47	62	49	Site: P<0.01 Species: 7
Sugar, g/kg	11	9	15	10	46	11	Species x Site: 4.9

- **Systems Analysis Plots**

Biomass yield and composition in the Systems Analysis plots also were analyzed/summarized (Table 5). Drought in 2012 reduced yields of all systems compared to previous years. Yield of the big bluestem-dominated prairie was very low (<0.5 Mg/ha) in 2012, while Miscanthus yielded in excess of 20 Mg/ha. Sorghum biomass yields were about 50% greater than maize. Biomass composition varied with system. Miscanthus had the highest cellulose concentrations, maize the lowest, with the other systems intermediate. Maize also had the lowest concentrations of hemicellulose and lignin of the systems studied. Because of grain present in the biomass, it was not surprising that the annual systems (maize, sorghum) had higher concentrations of starch and sugar when compared to the perennial systems.

Table 5. Biomass yield and composition of Shawnee switchgrass, a re-established big bluestem prairie, *Miscanthus x giganteus* dual-purpose (grain-biomass) sorghum, and maize (control) in Systems Analysis Plots at the Purdue University Water Quality Field Station in 2012. Biomass was analyzed for cell wall fractions (cellulose, hemicellulose, lignin), soluble sugars and starch.

Biomass System	Biomass Yield, kg/ha	Cellulose, g/kg	Hemicellulose, g/kg	Lignin, g/kg	Sugar, g/kg	Starch, g/kg
Switchgrass	3491	305	329	56	13	4
Prairie	491	303	297	57	10	2
Miscanthus	20788	418	301	87	12	13
Sorghum	15145	286	289	39	37	163
Maize	10636	158	210	20	29	246

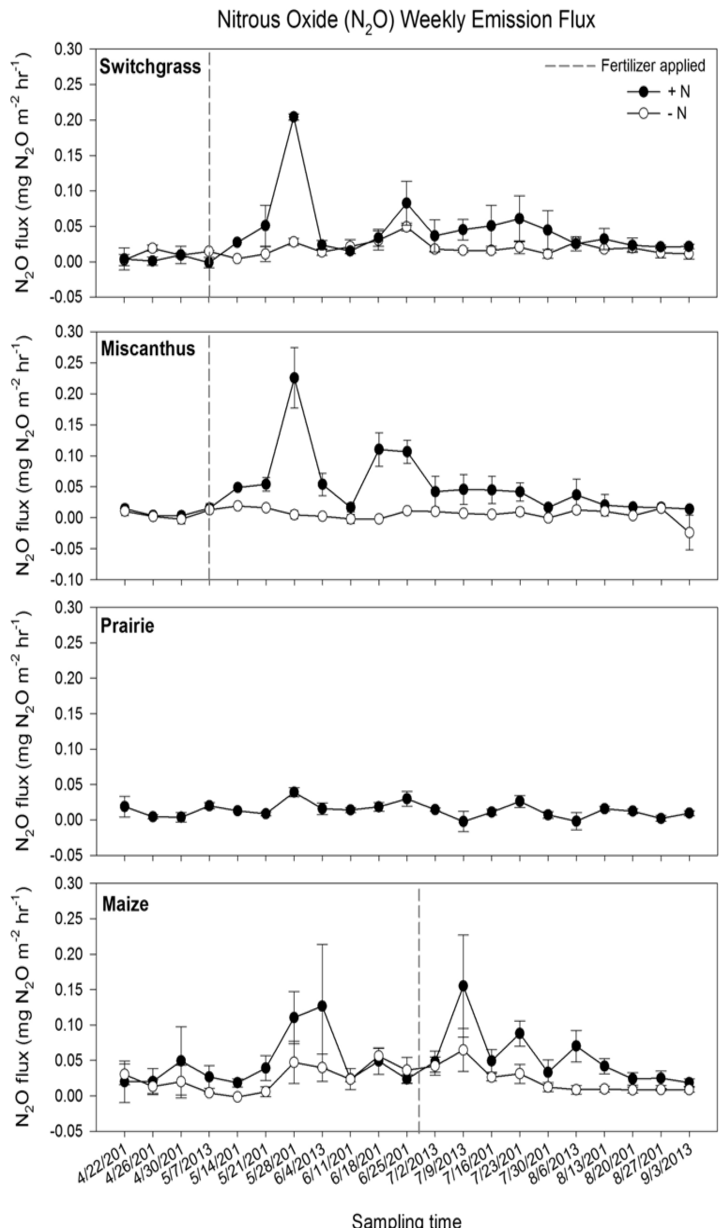


Figure 5. Seasonal patterns of nitrous oxide emission for switchgrass, *Miscanthus*, the indiangrass-big bluestem prairie, and maize (control). Plots of Shawnee switchgrass and Miscanthus were fertilized with 100 kg N/ha while maize received 150 kg N/ha at the times indicated by the vertical dotted line. The prairie plots were unfertilized.

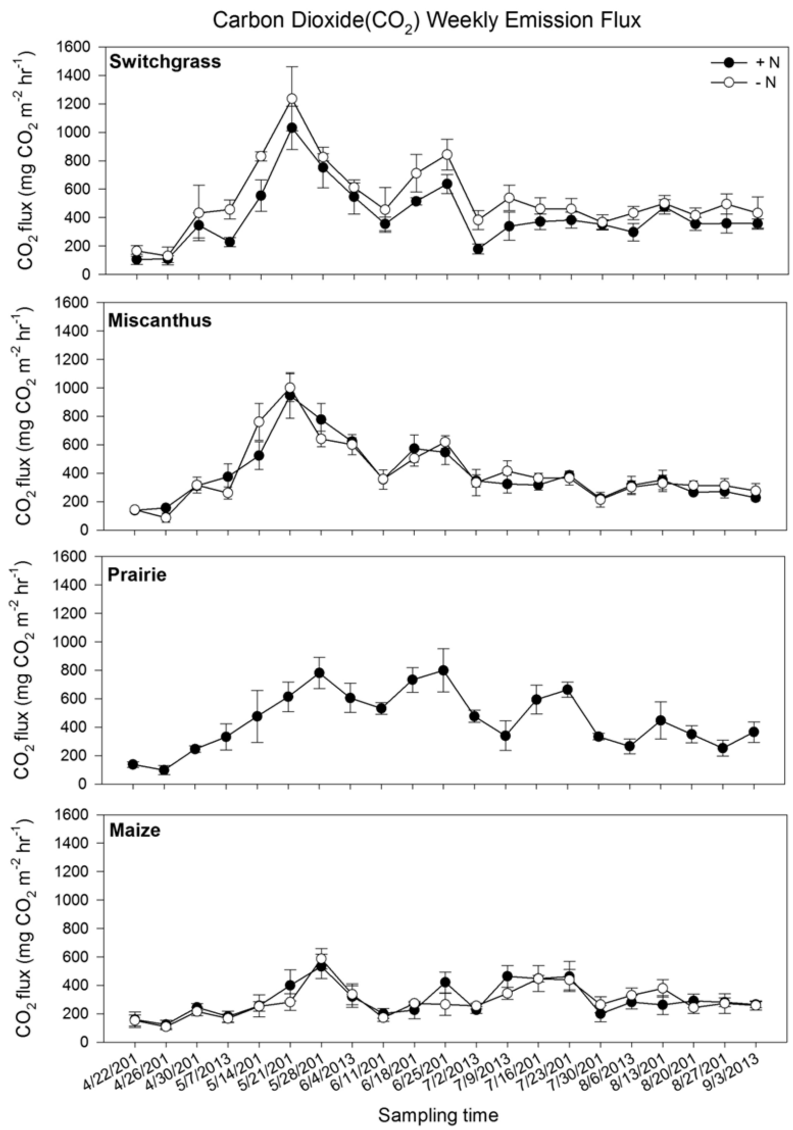


Figure 6. Seasonal patterns of carbon dioxide emission for switchgrass, Miscanthus, the indiangrass-big bluestem prairie, and maize (control). Plots of Shawnee switchgrass and Miscanthus were fertilized with 100 kg N/ha while maize received 150 kg N/ha at the times indicated by the vertical dotted line. The prairie plots were unfertilized.

Biomass yield and composition analysis were completed on a study aimed at benchmarking biomass performance of annuals like maize and sorghum to the perennials, while simultaneously determining the N use efficiency of these systems on marginal sites (Table 6). In 2012 yield of maize was severely reduced at all sites, but especially SEPAC where complete stand loss occurred. The response of maize to increasing N fertilization also was muted by the drought. Sorghum biomass yields were high at all three marginal sites and responded to N, with high yields generally obtained with 50 kg N/ha. In all three species, tissue N increased with greater N application even if biomass yield was unresponsive. Biomass carbon concentrations were generally unaffected by species, site, or N fertilization.

Table 6. Influence of nitrogen fertilizer on biomass yield and concentrations of nitrogen (N) and carbon (C) in biomass of maize, sweet sorghum, and photoperiod-sensitive (PS) sorghum. In order to permit comparison to the perennial biomass systems, these annuals were grown for biomass on the same marginal sites at the Throckmorton Purdue Ag Center (TPAC), the Northeast Purdue Ag Center (NEPAC), and the Southeast Purdue Ag Center (SEPAC) in 2012.

		Biomass yield, kg/ha			Biomass N, g/kg			Biomass C, g/kg		
Site	N rate, kg/ha	Maize	Sweet sorghum	PS-sorghum	Maize	Sweet sorghum	PS-sorghum	Maize	Sweet sorghum	PS-sorghum
TPAC	0	10789	13392	15002	11.6	8.0	9.4	453	445	448
	50	8268	13337	15346	12.4	9.6	11.9	446	443	451
	100	9411	13090	17263	12.3	9.8	11.2	450	448	448
	150	10195	14244	15901	13.0	11.0	12.8	448	445	451
	200	11672	13635	14783	13.6	11.8	13.2	447	445	452
NEPAC	0	3702	7666	8773	11.4	7.6	7.8	449	445	448
	50	4535	11382	13507	12.2	8.5	6.9	447	446	450
	100	3590	14028	15617	13.1	9.0	7.4	452	447	451
	150	3707	14596	15671	15.8	9.1	9.6	453	446	449
	200	4546	12309	15549	15.2	10.3	10.6	450	448	449
SEPAC	0	0	8129	12795	-	8.0	10.7	-	440	441
	50	0	13229	14699	-	8.7	8.5	-	441	445
	100	0	11762	11921	-	8.8	9.2	-	441	442
	150	0	13952	14460	-	9.8	11.3	-	440	446
	200	0	13222	16894	-	10.1	11.2	-	438	444

✓ **Understanding Landscape Impacts of Biomass Production Using Agricultural Policy/Environmental eXtender (APEX)**

Modeling of biomass production and hydrologic/water quality impacts of perennial crop production on marginal lands is continuing. Marginal land has been proposed as a viable choice for biomass crop production because it can help avoid competition between food and bioenergy production and brings environmental benefits. However, total biomass that could be produced from marginal land varied at different locations and the impacts on hydrology and water quality have not been evaluated. In this study, three types of marginal land were defined, including cropland and grassland with land capability class (LCC) 3 and 4, land located along stream buffers (10, 25, 50, and 100 m), and forest land located at 50 m buffer of current corn and soybean land. Total area was quantified in the St. Joseph River watershed based on National Agricultural Statistics Service (NASS) and Soil Survey Geographic Database (SSURGO) using ArcGIS software. Total biomass productivity was estimated using published field yield for switchgrass and Miscanthus and simulated yield for the two perennial crops with Agricultural Policy/Environmental eXtender (APEX) model. Impacts on hydrology and water quality were also evaluated using results from APEX simulation. Total area for three types of marginal land (when stream buffer was 100m) was 641 km2, about 23% of the watershed area. 45 million gallon bioethanol could be produced from switchgrass and 57 million gallon bioethanol could be produced from Miscanthus according to simulated yield. Area weighted average annual water yield might be decreased by growing switchgrass and Miscanthus compared to original land cover types when marginal land was converted. Water quality could generally be improved by reducing soil erosion and nutrient loss (nitrogen and phosphorus). These impacts on hydrology and water quality were non-ignorable across all watershed including marginal and non-marginal land even though they were statistically insignificant ($P<0.05$).

- **USDA-ARS, Lincoln**

  - All factor analysis plots seeded in 2012 and 2013 in Nebraska are fully established, with thin stands only in the bioenergy big bluestem plots seeded in 2013. August Harvest treatments were completed on the 2012 plots. Dry weights will be determined after post-frost sampling is completed. The 2012 feedstock samples are being prepared for NIRS analysis.

  - System analysis plots seeded in 2012 in Nebraska had excellent growth during the 2013 growing, even though precipitation was sporadic. The perennial grasses are growing well, with some lodging occurring as senescence progresses. Corn was harvested on 25 September, 2013. Corn yield on the areas seeded with a triticale cover crop in autumn 2012 was 138 bu/acre, whereas the yield on areas with no cover crop was 160 bu/acre. Weather and the government furlough have prevented stover removal to date, but the triticale cover crop was seeded into the standing stover after furlough. Perennial grasses will be harvested with field-scale equipment around Thanksgiving. Perennial grass biomass has been collected once per week throughout the growing season to provide biomass accumulation data and feedstock characterization. Based on Advisory Board recommendations at the Annual Meeting, a harvest height (2, 4, 6, 8, 10, and 12 inches) by harvest date (at anthesis and after killing frost) study was initiated in 2013 to determine feedstock response to harvest height and harvest date. Anthesis harvests were completed and post-frost harvests are in preparation. Dry weights will be determined after post-frost sampling is completed and samples will be processed during winter for future NIRS evaluation.

- Greenhouse gas (GHG) sampling was conducted throughout the 2013 growing season. GHG, soil water content, and biomass were sampled at weekly intervals in the System Analysis plots to compare the perennial grass feedstocks to continuous corn. Through 11 July, 2013, cumulative N2O emissions from corn were 4-5 times higher than emissions from any grass system. N treatments in grasses did not affect total N2O emissions. CO2 emissions were ~30% lower in continuous corn compared to bioenergy grasses. Data collected through the end of the growing season is being analyzed.

- Indirect biomass measurements have been conducted on the Nebraska System Analysis and all demonstration plots. Visual obstruction measurements (VOM) and elongated leaf height (ELH) for switchgrass, low diversity mixtures, and big bluestem were taken with the grassland assessment tool at about 7-d intervals from 14 June through 26 September, 2013 (Fig. 7). The declining VOM for Liberty switchgrass beginning with sample period 9 on 8 August illustrates the effect of lodging. VOM and ELH data will be used to evaluate indirect methods for estimating biomass in perennial feedstocks after drying and weighing is completed for all sampling periods. Predicting the current and end of season biomass yields quickly and accurately with VOM and ELH will help estimate biomass supplies.

Table 7. Mean (± se) total particulate organic matter (POM; mg g^{-1}) by subplot (n=6 each).

	Switchgrass		Big bluestem		Low diversity mix		Continuous corn	
Subplot	A	b	a	b	a	b	a	b
	mg total POM g^{-1} soil							
Soil depth								
0-5 cm	9.7 ± 0.6	11.0 ± 1.0	10.4 ± 1.0	9.1 ± 0.8	10.1 ± 0.8	10.1 ± 2.0	10.6 ± 1.2	12.7 ± 0.6
5-15 cm	2.8 ± 0.3	3.0 ± 0.3	3.3 ± 0.4	2.5 ± 0.5	2.6 ± 0.2	2.9 ± 0.6	3.2 ± 0.2	3.2 ± 0.2
15-30 cm	1.5 ± 0.1	1.9 ± 0.2	1.5 ± 0.2	1.8 ± 0.2	1.8 ± 0.2	1.7 ± 0.2	2.4 ± 0.5	2.0 ± 0.4
30-60 cm	1.1 ± 0.1	1.4 ± 0.2	0.9 ± 0.1	1.2 ± 0.1	1.2 ± 0.2	1.1 ± 0.1	1.8 ± 0.5	1.8 ± 0.5
60-90 cm	0.8 ± 0.1	0.9 ± 0.2	0.9 ± 0.1	1.0 ± 0.1	0.8 ± 0.1	0.6 ± 0.2	1.7 ± 0.6	1.3 ± 0.4
90-120 cm	0.8 ± 0.1	1.4 ± 0.3	1.0 ± 0.1	1.0 ± 0.1	0.9 ± 0.1	0.8 ± 0.1	1.3 ± 0.2	1.3 ± 0.3

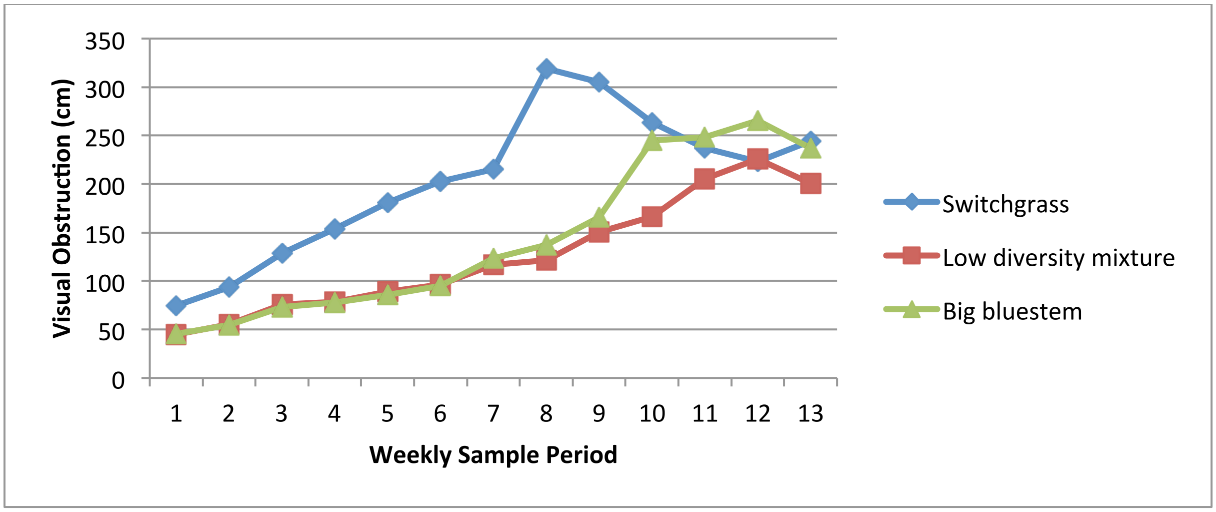


Fig. 7. Visual obstruction measurements (VOM) for switchgrass, low diversity mixtures, and big bluestem near Mead Nebraska in 2013. Measurements were taken with the grassland assessment tool at about 7-d intervals from June 14 through September 26, 2013.

- The baseline soil particulate organic matter and particle size analysis was completed on the System Analysis Plots. Two cores per subplot were randomly selected for analysis of total particulate organic matter (POM; Table 7) and particle size analysis (% sand, silt, clay; Table 8) for all depth increments. In addition to total POM, coarse POM (0.5 – 2.0 mm DIA) and fine POM (0.053 – 0.5 mm DIA) was determined in the two surface soil increments (0-5 cm, 5-15 cm; Fig. 8). Reported values are treatment means and standard errors, unless otherwise noted.

- Collaborations:

  ✓ Worked with the Systems Performance Objective to conduct a field day in Wisconsin in September 2013 to showcase herbaceous perennial feedstock establishment.

  ✓ Completed the final drafts for two CenUSA fact sheets on switchgrass management.

  ✓ Discussed additional wildlife research opportunities with the *Nebraska Game and Parks Commission and the National Wildlife Federation.*

  ✓ Finalized the National Wildlife Federation best management guidelines for perennial grasses for bioenergy.

  ✓ Summarized the Shawnee and Liberty switchgrass data from the ADM fractionation procedure and evaluated the five fractions with bomb calorimetry (Table 9).

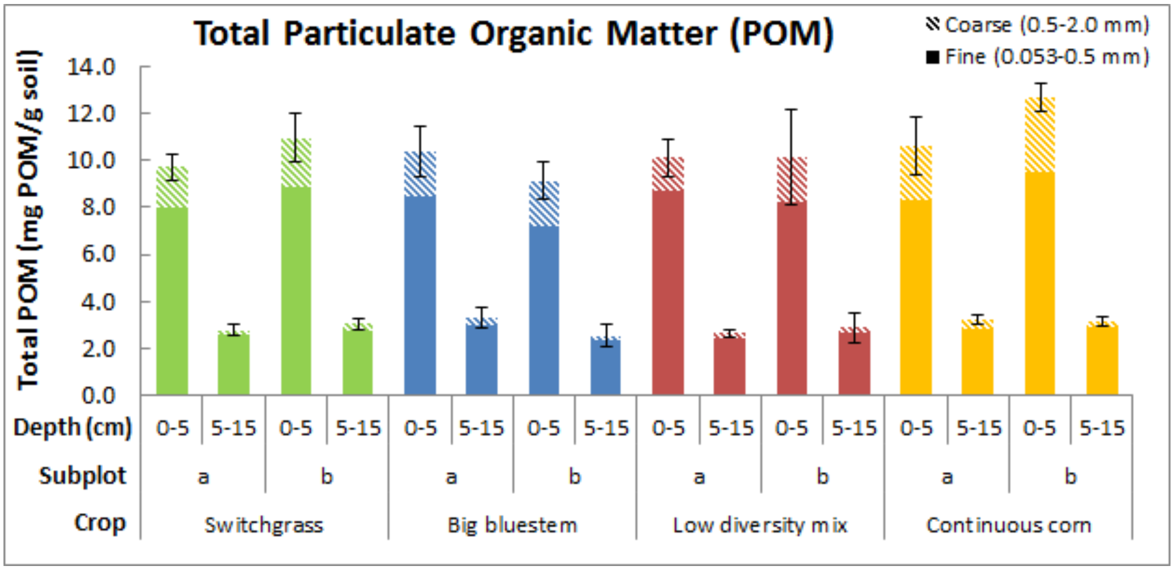


Fig. 8. Mean coarse, fine, and total POM in surface soils by subplot (n=6 each). Standard error bars are for mean total POM.

Table 8. Mean (± se) particle size analysis (%) by subplot (n=6 each). Soil textural class (TC) denoted by sl = silt loam, scl = silty clay loam.

		Subplot A				Subplot B			
		Sand	Silt	Clay	TC	Sand	Silt	Clay	TC
		%				%			
Crop	Depth (cm)								
Switchgrass	0-5	7.9 ± 0.8	65.9 ± 1.7	26.2 ± 1.1	sl	7.5 ± 1.6	68.0 ± 1.6	24.5 ± 1.6	Sl
	5-15	4.0 ± 0.4	64.0 ± 3.2	31.9 ± 3.1	scl	4.1 ± 2.5	64.1 ± 2.5	31.9 ± 2.5	scl
	15-30	3.1 ± 0.1	63.7 ± 2.0	33.1 ± 1.9	scl	4.0 ± 3.6	64.4 ± 3.3	31.6 ± 3.6	scl
	30-60	5.6 ± 0.4	64.1 ± 1.9	30.3 ± 1.6	scl	5.4 ± 1.8	66.0 ± 2.0	28.5 ± 1.8	scl
	60-90	3.0 ± 0.3	62.9 ± 2.4	34.1 ± 2.2	scl	4.7 ± 3.0	64.2 ± 2.4	31.0 ± 3.0	scl
	90-120	3.5 ± 0.5	63.7 ± 2.8	32.8 ± 2.4	scl	4.3 ± 1.7	60.4 ± 1.9	35.4 ± 1.7	scl
Big Bluestem	0-5	7.6 ± 0.9	62.5 ± 0.7	30.0 ± 0.9	scl	7.7 ± 1.2	65.1 ± 1.1	27.2 ± 1.2	sl
	5-15	4.3 ± 2.8	60.8 ± 2.7	34.9 ± 2.8	scl	4.9 ± 2.6	62.9 ± 2.3	32.2 ± 2.6	scl
	15-30	3.8 ± 1.4	60.3 ± 1.4	35.9 ± 1.4	scl	4.4 ± 1.9	62.7 ± 2.0	32.8 ± 1.9	scl
	30-60	5.7 ± 1.1	60.6 ± 1.2	33.7 ± 1.1	scl	5.8 ± 1.4	63.2 ± 1.2	31.1 ± 1.4	scl
	60-90	4.3 ± 1.4	63.0 ± 1.6	32.7 ± 1.4	scl	4.2 ± 1.0	63.7 ± 1.2	32.1 ± 1.0	scl
	90-120	5.0 ± 2.7	64.5 ± 2.5	30.5 ± 2.7	scl	4.4 ± 1.4	64.5 ± 1.6	31.0 ± 1.4	scl
LD mix	0-5	7.6 ± 1.2	68.0 ± 1.1	24.4 ± 1.2	sl	7.4 ± 1.3	66.4 ± 1.1	26.2 ± 1.3	sl
	5-15	4.2 ± 1.5	68.0 ± 1.4	27.8 ± 1.5	scl	4.9 ± 3.3	63.5 ± 3.1	31.6 ± 3.3	scl
	15-30	3.5 ± 1.7	63.6 ± 1.5	32.9 ± 1.7	scl	4.2 ± 2.0	61.6 ± 2.0	34.1 ± 2.0	scl
	30-60	5.0 ± 1.0	67.0 ± 1.0	28.0 ± 1.0	scl	5.7 ± 1.2	64.2 ± 1.0	30.1 ± 1.2	scl

	60-90	3.7 ± 1.8	60.5 ± 2.0	35.8 ± 1.8	scl	4.0 ± 0.9	61.9 ± 0.9	34.1 ± 0.9	scl
	90-120	4.4 ± 1.4	63.9 ± 1.3	31.7 ± 1.4	scl	6.6 ± 1.5	62.3 ± 1.9	31.1 ± 1.5	scl
Corn	0-5	8.5 ± 2.2	65.8 ± 2.0	25.7 ± 2.2	sl	9.1 ± 1.6	69.1 ± 1.4	21.9 ± 1.6	sl
	5-15	5.6 ± 5.1	70.0 ± 4.3	24.3 ± 5.1	sl	3.9 ± 2.7	65.6 ± 2.7	30.4 ± 2.7	scl
	15-30	4.8 ± 2.1	62.5 ± 1.9	32.6 ± 2.1	scl	4.0 ± 1.7	63.0 ± 1.9	33.0 ± 1.7	scl
	30-60	5.4 ± 1.5	65.7 ± 1.6	28.9 ± 1.5	scl	5.8 ± 1.4	67.4 ± 1.3	26.8 ± 1.4	sl
	60-90	4.4 ± 1.3	61.2 ± 1.9	34.4 ± 1.3	scl	4.0 ± 1.1	62.2 ± 1.8	33.8 ± 1.1	scl
	90-120	4.4 ± 2.9	61.3 ± 3.0	34.3 ± 2.9	scl	4.6 ± 0.9	61.3 ± 1.5	34.0 ± 0.9	scl

- **USDA-ARS, Madison**
  - **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 establishment 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 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.

Table 9. Mean calories per gram based on bomb calorimetry for insoluble lignin, soluble lignin, cellulose, hemicelluloses syrup, and soluble fractions for Shawnee and Liberty switchgrass following ADM fractionation. The soluble lignin fraction was missing for Shawnee.

	Insoluble Lignin	Soluble Lignin	Cellulose	Hemicellulose Syrup	Soluble Fraction
			cal g^{-1} of Fraction		
Shawnee	5796	---	3687	3335	3980
Liberty	5846	5227	3980	3263	4051

- **Actual Accomplishments**

  Biomass yield, soil samples, and biomass-quality samples were collected at two locations in Wisconsin (Arlington and Marshfield), HZ4 and HZ3, respectively. Harvest stages and dates were: anthesis (mid-August) and killing frost (mid-October).

- **Explanation of Variance**

- **Plans for Next Quarter**

  ✓ The third harvest treatments (post soil-freeze and pre-snow) will be made in late November.

  ✓ Samples from the first two harvests will be ground and scanned on NIRS.

  ✓ Data from the first two years will be summarized and analyzed in preparation for writing a manuscript.

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

  None.

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:

- Time and motion studies of bale handling logistics;
- Field evaluation of machine configurations to combine cutting/intensive conditioning/tedding; and
- Establishment of native grass fields for demonstration and research use.

2. Actual Accomplishments

Several fields of native grasses 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 experience experienced operator loaded bales onto trailers and bale handling quantified by time, distance traversed, and fuel use per bale. Strategic bale accumulation continues to have greatest impact when only one person is available to both load bales and move the trailer. 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 fewer saving. When yield exceeds about 3 tons DM/acre; strategic bale placement also has less value.

In 2012, we determined that the drying rate of switchgrass was enhanced by both intensive conditioning and wide-swath drying. In the last quarter, we finished development of a combined machine to cut; intensively condition, and ted the crop in a single operation. This uses front-mounted mower on a tractor that also pulls an intensive conditioner equipped with a mounted tedder. This re-configuration is now capable of completing three operations – cutting, intensive conditioning and wide-swath tedding in a single-pass, eliminating two field operations. Drying trials with the tri-function machine were conducted after a hard-freeze using switchgrass. Compared to traditional harvest practices, the tri-function machine typically reduced time to safe baling moisture from three to two days. Crop that was intensively conditioned and tedded was typically ready for baling by noon of the day after cutting. The tri-function machine worked capably in high-yielding switchgrass with no issues related to plugging or diminished capacity.

Finally, we have rented 32 acres of marginal land in which we will establish a variety of perennial grasses. The fields have been planted in mixtures of switchgrass, big bluestem, and indiangrass. Both switchgrass and the native grasses have established well. A grass establishment outreach field day was conducted on September 19, 2013 with Rob Mitchell conducting most the discussion on the proper techniques to insure grass establishment success. About thirty participants attended the event, mainly from local governmental agencies. The field has been baled with yield of about 2 tons DM/ac.

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:

- Now that our fall harvest period is nearly completed we plan to:
- Analyze the collected data from the 2013 harvest and prepare manuscripts;

- Continue to collect post-storage size-reduction energy requirements of bales, but now using bales removed from storage during the winter months;
- Work with a local manufacturer to develop a test plan for a high-density baler which we plan to evaluate using over-wintered grasses in the spring of 2014; and
- Perform field operations to insure successful overwintering of our native grass demonstration field established in 2013.

5. Publications, Presentations, and Proposals Submitted

- Shinners, K. (2013: September 10-12). *Challenges in the Production of Biomass Feedstocks From Perennial Grasses.* Oral presentation and field demonstration at Switchgrass II, Madison, WI.
- Shinners, K; Mitchell, R., Porter, P. & Friede, J. (2013: September 20). *Establishment of Perennial Grasses. Field Demonstration*. Edgerton, WI.

Iowa State University

1. Planned Activities

Research activities planned during the fall of 2013 included:

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

2. Actual Accomplishments

- Laboratory tests in a controlled environment to determine dry matter loss and leaching of minerals from biomass materials are in progress. The information collected is being analyzed to develop dry matter loss and mineral leaching models and to evaluate the respect effect on biomass feedstock quality.
- Data is being collected for field scale machine performance and logistics data for large-scale harvest and transportation of biomass. Over the next quarter, the information will be analyzed to update machine performance data for harvest operations.

3. Explanation of Variance

Only minor variance in planned activities has been experienced. The completion of the laboratory testing equipment was delayed due to installation problems, but this was resolved. This slightly delayed initial tests, but did not significantly impact the work

4. Plans for Next Quarter

Research activities planned during next quarter include:

- Development and integration of improved dry matter loss models into field harvest and logistics cost model.
- Analysis of field scale machine performance and logistics data for large-scale harvest and transportation of biomass materials.

5. Publications, Presentations, and Proposals Submitted

- 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.

Iowa State University

1. Planned Activities

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

We continue to work on the improvement of SWAT models for the Upper Mississippi River Basin and the Ohio Tennessee River Basin with USGS 12-digit subwatersheds. During the previous quarter, we have completed the calibration and a manuscript is under preparation. 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 provides 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. We are beginning the process of developing scenarios relevant to biofuels

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. Scenarios related to placement of cellulosic biofuels on marginal lands are being developed; we hope to have preliminary results by the end of this quarter.

5. Publications, Presentations, and Proposals Submitted

- Kling, Catherine, L. (2013: August). *Optimal placement of Second Generation Biofuels in a Watershed: Is Marginal Land the Answer?* Presentation at the annual meetings of the Association of Agricultural and Applied Economics, Washington DC.
- Kling, Catherine L. (2013: October 11). *Agricultural Water Pollution: Some Policy Considerations*. Presentation at the Iowa Environmental Council Annual Meeting. Available at http://www.card.iastate.edu/presentations/iowa_enviornmental_council._oct_2013.pptx
- Kling, Catherine L., (2013: October 15). *Linking Externalities from the Land to their Consequences in the Sea: A Model of Land Use, Costs, Hydrology and the Gulf of Mexico Hypoxic Zone.* Presentation at the Water Resources Conference, Saint Paul,

Minnesota. Available at: www.card.iastate.edu/presentations/linking_externalities_from_land_to_sea.pptx

- Schilling, Keith E., Gassman, Philip W., Kling, Catherine L., Campbell, Todd, Jha, Manoj, Wolter, Calvin F. and Arnold, Jeffrey G. (2012: June). 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
- Valcu, Adriana Mihaela, "Agricultural nonpoint source pollution and water quality trading: empirical analysis under imperfect cost information and measurement error" (2013). *Graduate Theses and Dissertations.* Paper 13444. Available at: http://lib.dr.iastate.edu/etd/13444

University of Minnesota

1. Planned Activities

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); 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 life cycle environmental consequences of various bioenergy landscapes).

2. Actual Accomplishments

Our major accomplishment this quarter was hosting the conference *Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops* in Minneapolis (September 23-24 2013). We also fielded responses from our paper comparing U.S. federal agency bioenergy feedstock production scenarios for achieving Renewable Fuel Standard (RFS2) biofuel volumes. We continue our analyses of switchgrass and corn trial yields in our investigation of yield gaps, and compiling of production cost and return data for switchgrass.

3. Explanation of Variance.

No variance has been experienced.

4. Plans for Next Quarter

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

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

- *Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops*. (2013: September 23-24). Held with Joint Hypoxia Task Force: Minneapolis, Minnesota, http://water.epa.gov/type/watersheds/named/msbasin/.

- 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. 47: 11095–10101. DOI: 10.1021/es402181y.

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**.

   Develop novel experimental method for mild catalytic pyrolysis (MCP) process using ZSM5 catalyst.

2. **Actual Accomplishments**.

   - Developed a plan experimental analysis.

   - Carried out screen analysis for methods that can be used for experiments.

   - Conducted experiments for the aqueous mix methods with results analysis. Figure 10 shows the results of the screening analysis for different methods.

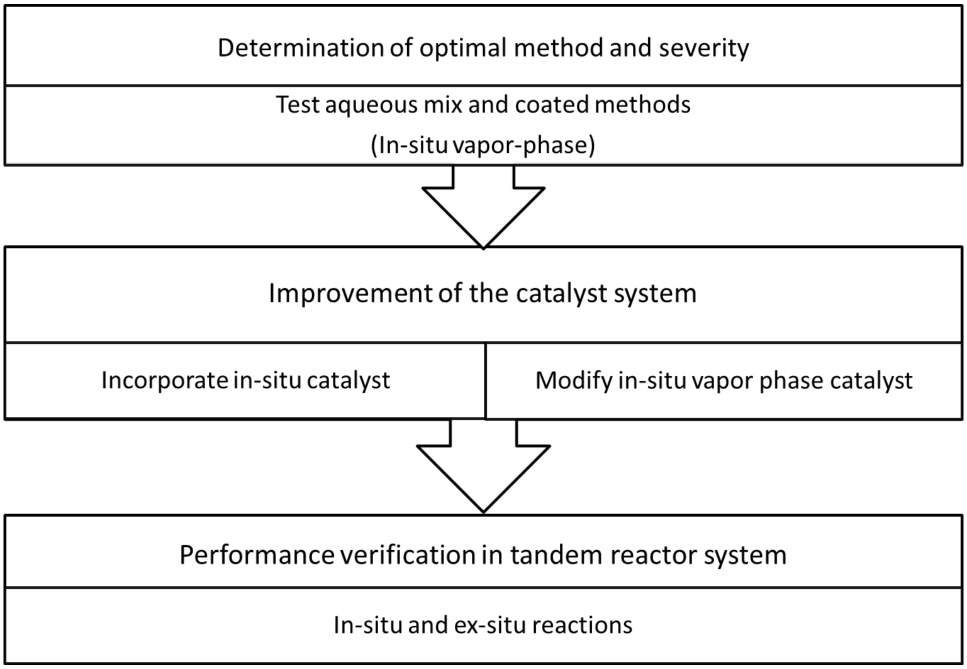


Fig. 9. Experimental plan for improving mild catalytic pyrolysis reactor system

	Nano Silica	Silica Gel	Sand	Silicon Carbide
Solid mix	Low Yield	Not Uniform	X	X
Aqueous mix	OK	Low and Different Product	X	X
Wash coating (experimental)	X	X	Good Yield Not uniform	Low Adherence
ZSM 5 Nucleation	X	X	Future	Future

Fig. 10. Screen analysis for different catalyst bed preparation methods

Preliminary results for ZSM5 to Red Oak loadings of between 0.2 and 1.4 were collected and are shown in Figure 11. These results indicate an increase in aromatic yields and decrease in holocellulose and lignin-derived compounds with higher ZSM5 loading.

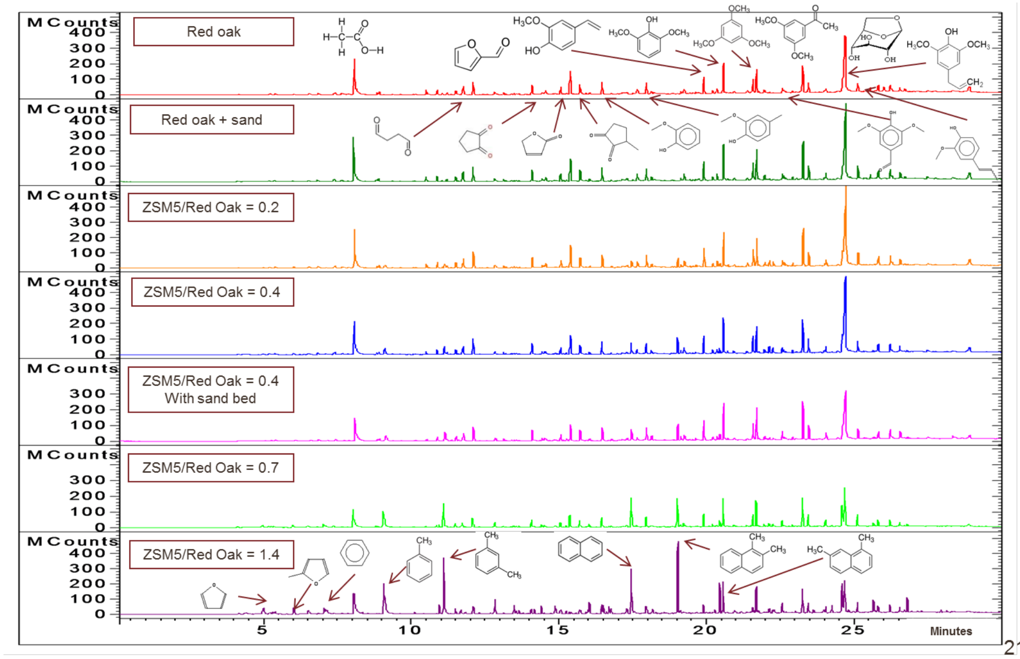


Fig. 11. Red oak mild catalytic pyrolysis product comparison with varying ZSM5 to Red Oak loading ratios

3. Explanation of Variance.

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter.

- Carry out experimental analysis to obtain the optimum method to be used in MCP systems.
- Develop a plan and carry out catalyst screening experiments.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Sub-objective 2. Prepare and characterize biochar

1. Planned Activities.

- Revise the Boehm titration manuscript to address the reviewer comments and return the manuscript to JEQ for a final decision on publication.

- Conduct data analysis and interpretation for a biochar characterization manuscript.
- Conduct additional X-ray diffraction and FTIR analyses to complete the date set needed for the characterization manuscript.
- Prepare a first draft of the biochar characterization manuscript.

2. **Actual Accomplishments**.

- Revisions and responses to reviewer comments for the Bohem titration paper were returned to the associate editor of the *Journal of Environmental Quality* and the manuscript has been formally accepted for publication. Proofs of the paper were received, reviewed and returned to the editor. The manuscript should appear on-line shortly.
- A first draft of the biochar characterization paper was prepared. The focus of the manuscript is on quantifying anion exchange capacity of biochars and identifying the surface functional groups that are responsible for causing AEC of biochars. The following paragraph is a synopsis of the data and an analysis, which leads us to conclude that the biochars contain oxonium cations are primarily responsible for AEC.

  As shown in Figure 12, X-ray diffraction patterns of the alfalfa meal and corn stover biochars show evidence of inorganic phases even after treatment 1 M HCl for 24 hr. and 0.1 M HCl + 0.3 M HF for 36 hr. The results suggest that some inorganic phases are occluded within the organic C matrix of these biochar. X-ray diffraction analysis of the cellulose biochar, however, showed no sign of inorganic phases, which is consistent with the chemical analysis, which showed only trace levels of inorganic elements in the cellulose biochar. Because the cellulose biochar contains negligible levels of inorganic material it is appropriate to assume that all of the O in the biochar sample is associated with the organic C phase. The results in Table 10 show significant levels of O in the cellulose and amino acid biochars, which is assumed to be structural.

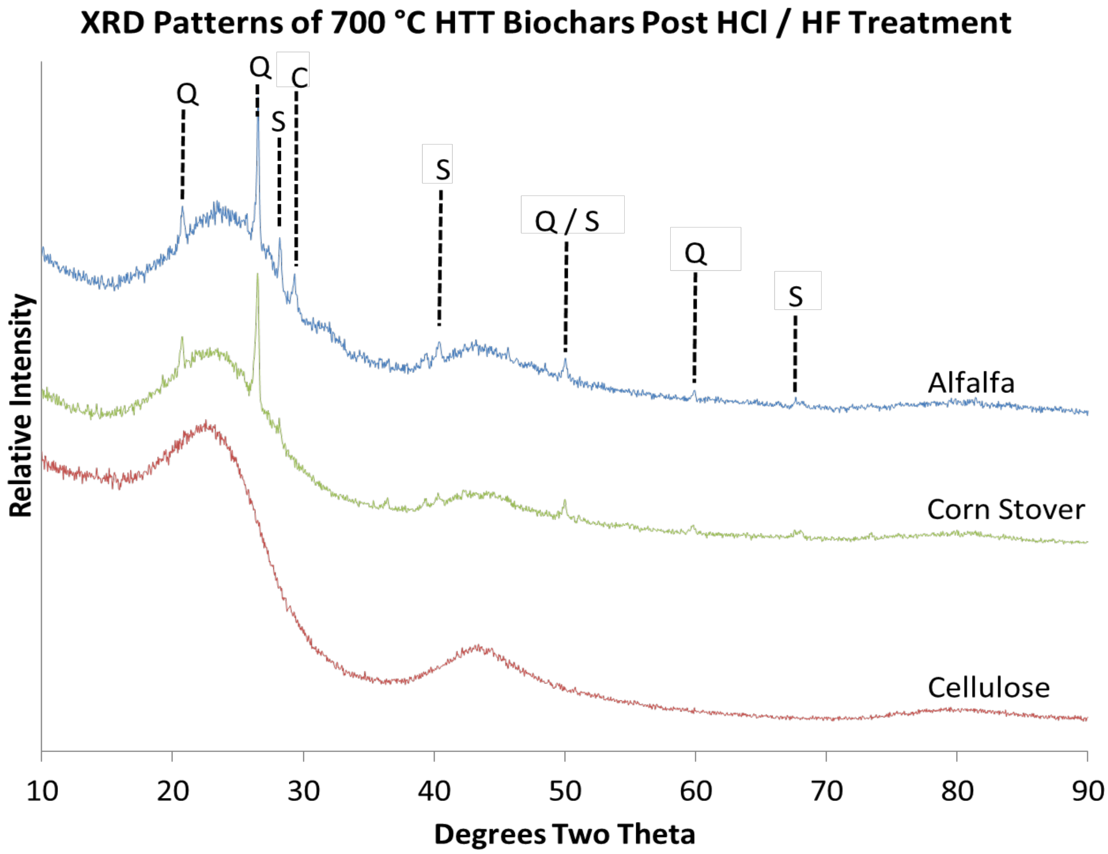


Fig. 12. X-Ray diffraction analysis of HCl/HF treated biochars

Table 10. Chemical analysis and physical properties of biochars prepared from alfalfa meal, cellulose, corn stover, and reagent grade lysine and methionine at two different temperatures 500 and 700°C.

Feedstock	HTT (°C)	Yield (%)	Element Content (%)					pH	Ash (%)	BET-N_2 (m^2/g)	Particle Density (g/cm^3)
			C	N	H	S	O				
Alfalfa	500	29.8	66.03	3.40	2.43	0.18	**	10.0	28.84	30	1.61
Alfalfa	700	29.0	68.80	3.23	1.45	0.25	**	10.0	30.89	176	1.90
Cellulose	500	27.9	84.80	0.00	2.98	0.08	10.82	8.3	0.87	321	1.34
Cellulose	700	26.0	90.30	0.01	1.72	0.12	6.12	8.6	0.92	229	1.68
Corn Stover	500	31.5	75.45	1.48	2.67	0.08	**	10.1	20.03	150	1.56
Corn Stover	700	29.8	77.54	1.23	1.48	0.13	**	10.2	21.93	259	1.74
Lysine	500	*	80.17	12.63	3.13	0.06	4.01	*	*	*	*

Lysine	700	*	82.32	12.17	1.37	0.18	3.95	*	*	*	*
Methionine	500	*	72.63	12.10	3.01	0.62	11.63	*	*	*	*
Methionine	700	*	61.08	8.56	1.44	4.72	24.20	*	*	*	*

FTIR analysis of the prepared biochars (Figure 13) showed small adsorption bands for hydroxyl and carbonyl functional group. These peaks are too small to account for the levels of O found in the cellulose, lysine, and methionine biochars (Table 10). Thus we conclude that a significant amount of the O must be present in the form of O-heterocycles. The FTIR analysis shows a strong adsorption band at 1590 cm^{-1}, which we have identified as C-O stretching band for O-heterocycles.

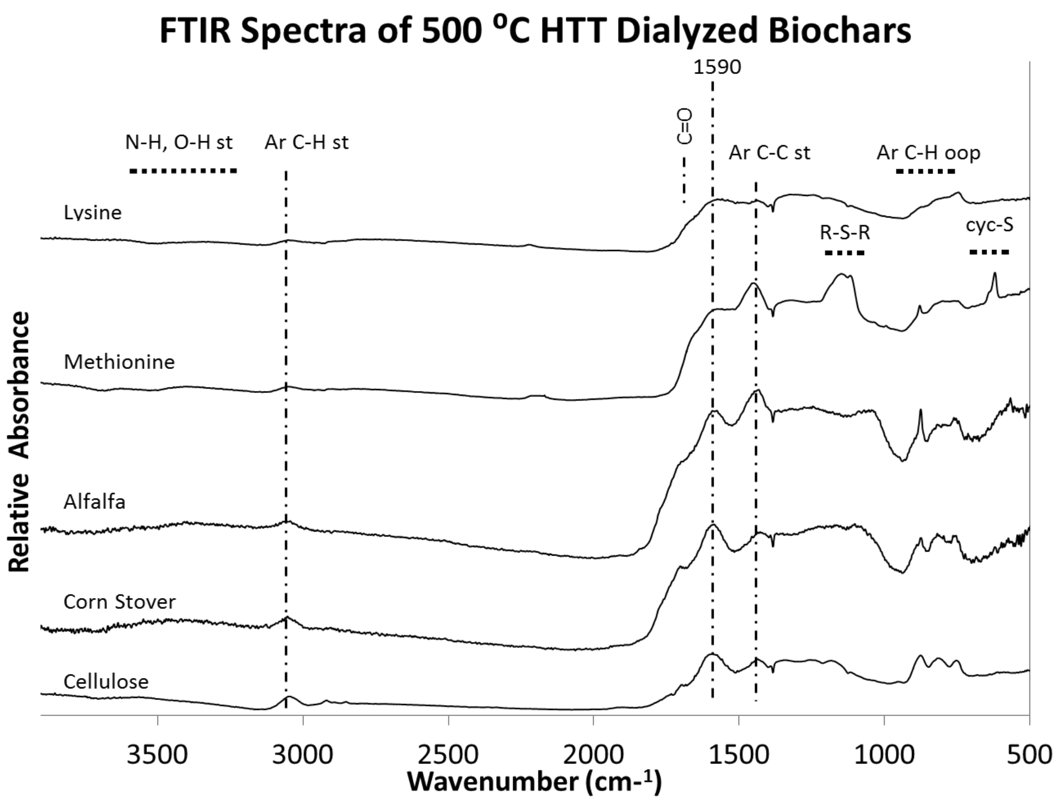


Fig. 13. FTIR Spectra of 500°C Dialyzed Biochars

Anion exchange capacity of the studied biochars (Table 11) varied from 0.602 to 27.76 cmol kg-1. The AEC generally increased with decreasing pH and increased with pyrolysis temperature.

Table 11. Average anion exchange capacities of the studied biochars. Numbers in parentheses are standard deviations.

Feedstock	HTT (^{0}C)	pH 4 (cmol kg^{-1})	pH 6 (cmol kg^{-1})	pH 8 (cmol kg^{-1})
Alfalfa	500	10.88 (2.461)	3.095 (0.279)	0.938 (0.338)
Alfalfa	700	25.85 (4.083)	9.64 (1.075)	2.15 (0.871)
Cellulose	500	7.84 (1.938)	2.63 (0.211)	0.602 (0.372)
Cellulose	700	24.23 (5.944)	18.07 (8.656)	4.11 (0.182)
Corn Stover	500	17.51 (5.808)	3.77 (0.658)	1.05 (0.206)
Corn Stover	700	27.76 (9.098)	13.82 (4.225)	7.19 (1.39)

Based on the above evidence we conclude that AEC in biochars is primarily due to oxonium functional groups which are formed during pyrolysis and that the surface density of oxonium functional groups increases with the peak pyrolysis temperature.

This research adds to basic understanding of biochar surface chemistry and how feedstock type and pyrolysis temperature influence biochar surface chemistry. The research also suggests that it may be possible to optimize pyrolysis conditions to generate high AEC biochars, which would add value to biochar due to the increased ability to retain anionic nutrients such as nitrate and phosphate.

3. **Explanation of Variance**.

   No variance has been experienced and accomplishments are on schedule.

4. **Plans for Next Quarter**.

   We will begin work on preparing a manuscript documenting the stability of biochar AEC, a harsh oxidizing environment. Additional chemical and spectroscopic analysis will be conducted as needed to complete this paper.

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

1. Planned Activities

Our team anticipated a total of four activities for the first quarter of the project's third year.

- Jacobs will work with the CenUSA Extension Objective to develop plans to administer the *Adoption of Switchgrass Production Survey*. As with the pilot survey given during quarter 1 of year two 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 be developed over several quarters.
- 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 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 (Hayes).
- Continue modeling and analysis efforts of the regional supply curve for grasses and stover using a real options framework (Hayes). Present one of these at conference on this subject in 2014. Publish two peer-reviewed papers in this area.
- Construct the budgeting analysis of threshold returns necessary to make biomass production feasible under various yield regimes and land use alternatives (Perrin).

2. Actual Accomplishments

- *Adoption of Switchgrass Production Survey*. CenUSA project information will be presented at this year's Integrated Crop Management Conference at Iowa State University. Keri Jacobs and Chad Hart will present an update on the project and associated economics and administer a similar survey.
- Modeling the use of feedstocks as a fuel source for fast pyrolysis. This activity is on-going.

- Modeling and analysis efforts of the regional supply curve for grasses and stover using a real options framework. This activity is on-going.
- Constructing the budgeting analysis of threshold returns necessary to make biomass production feasible under various yield regimes and land use alternatives. This activity is on-going.

3. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

4. Plans for Next Quarter

- Administer the switchgrass survey and develop a report for CenUSA colleagues.
- All other planned activities will continue.

5. Publications, Presentations, and Proposals Submitted

- **Perennial Grasses for Bioenergy in the Central United States: Updates on Economics and Research Progress** (Keri Jacobs, assistant professor and Extension economist, Economics, Iowa State University).

  Through policies and programmatic commitments, the United States is exploring the use of alternative transportation fuels as means to meet the growing global demand for energy and the nation's RFS targets. The CenUSA Bioenergy project is a five-year, multi-state, and multi-disciplinary coordinated research and education effort to develop a sustainable system for the production of biofuel feedstocks derived from perennial grasses on land marginal for row crop production. Now in its third year, the project, funded by the USDA under the NIFA-AFRI Sustainable Biofuels Initiative (project #2010-05074), focuses on the production of perennial grasses integrated within the row crop landscape in the region consisting of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.[4] CenUSA is comprised of researchers, scientists, and educators working in nine objective areas to move the project forward: 1) feedstock development, 2) sustainable production systems, 3) feedstock logistics, 4) system performance, 5) feedstock conversion, 6) markets and distribution, 7) health and safety, 8) education, and 9) extension and outreach.

[4] The project is led by Iowa State University and partners with researchers and scientists at Purdue University, University of Illinois – Champaign, University of Minnesota – Twin Cities, University of Vermont – Burlington, University of Wisconsin – Madison, and the USDA ARS – Ames, Iowa; Lincoln, Nebraska; Wyndmoor, Pennsylvania; Madison, Wisconsin.

A feasible and sustainable regional system of biofuels derived from perennial grasses requires a comprehensive strategy that addresses impacts to and requirements of markets and distribution systems. The markets and distribution platform (Objective 6) is responsible for, among other things, evaluating farm-level adoption decisions and exploring policy, market, and contract mechanisms that facilitate broad scale adoption by farmers. Recognizing that adoption by farmers will be voluntary, the production of biomass for biofuels must be shown to have economic value to the farmers who will be considering it in their farm business management decisions. Further, switchgrass production must be competitive with traditional row-crop production on the same quality land.

Placement of switchgrass for the purpose of biofuels is envisioned to be on lands unsuitable or marginal for row crop production; lands near streams and waterways are of particular interest. The U.S Department of Energy estimates that nearly 20 million hectares of land in the United States is available to support perennial grasses for bioenergy crops (2011). One placement scenario the CenUSA project is considering is plantings of biomass crops on current or past Conservation Reserve Program (CRP) lands. Switchgrass may provide a return advantage to the farmer over the CRP and alleviates contractual obligations that accompany CRP enrollment. However, unlike the steady CRP payment, switchgrass production is susceptible to weather, production, and marketing risks. Further, current high commodity prices make production on marginal lands, even past CRP lands, profitable.

Farm scale production costs of switchgrass, including those for establishment, management, harvest, and storage, have been estimated at $65.86 per metric ton of biomass dry matter (2003 prices, includes land cost of $147.45/ha ($60/acre)) over a 5-year rotation with biomass-type cultivars expected to yield approximately 5.0 metric tons per hectare (Perrin et al. 2012). Cost projections are lower for a 10-year rotation of switchgrass with a slight drop in yields in later years of the rotation.

The economic return to switchgrass production for landowners includes not only the coverage of costs by expected returns from marketing, but also an accounting of the additional on-farm benefits the system may provide, such as erosion control benefits and the value of biochar as a soil amendment. Social benefits from the reduction of nutrient run-off and greenhouse gas emissions could be substantial. CenUSA collaborators estimate that switchgrass production results in an increase of long-term carbon sequestration, particularly at the deeper soil depths (0 to 150 cm), and are working to quantify these and other impacts of the perennial grass system and their economic value.

During Iowa State University's *2012 Integrated Crop Management Conference*, producers and farm managers were provided information regarding switchgrass production decisions and the expected costs and returns of a perennial grass system based on the current state of a perennial grass system based on the project's feedstock development progress and the expected economics associated with production in this region. The participants were then surveyed to gain feedback on their perceptions of a perennial grass production system and its ability to compete with traditional cropping systems. This year's session will update participants with recent advancements in CenUSA's project, discuss their impact on the financial feasibility of perennial grasses in light of current economic and legislative conditions, and discuss the key variables that will drive the success of this effort based on last year's survey results.

References

Perrin, R., K. Vogel, M. Schmer & Mitchell, R. (2008). Farm-Scale Production Cost of Switchgrass for Biomass. Bioenergy Research, 1(1): 91-97. Available at: http://www.springerlink.com/content/f85977006m871205/.

U.S. Department of Energy. (2011). *U.S. billion-ton updated: biomass supply for a bioenergy and bioproducts industry.* In: Perlack RD, Stokes BJ (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN.

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

A hierarchy of various subheadings is being developed for major various tasks associated with producing biofeedstocks. The major headings main tasks are:

- Establishment
- Maintaining

- Harvest
- On-site processing and storage
- Transportation

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

b. Actual Accomplishments

Progress continued on refining the listing of tasks/responsibilities for biofeedstock production. The listing is currently contains seven “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. Diversity of equipment used 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 are being evaluated for the various tasks. These tools are Frequency/Severity Analysis, Deviation Analysis, and Fault Tree Analysis. Each Action is being assessed using these three tools. A partial list of expected risks with enumerated tasks has been completed.

The team reinforced the cooperative arrangement with the investigator at Penn State University by collaborating for two presentations at the *2013 North American Agricultural Safety Summit*.

c. Explanation of Variance

None to report.

d. Plans for Next Quarter

Assessment of the three risk assessment tools will continue. The tools will be used to evaluate various actions within Main Tasks/Task Grouping/Tasks/Actions. It is expected that the standard risk assessment tool to use for tasks in biofeedstock production may ultimately be a hybrid of the three tools under investigation.

e. Publications, Presentations, and Proposals Submitted

A presentation was made at the Biomass and Biofuels session of the 2013 North American Agricultural Safety Summit hosted by Agricultural Safety & Health Council of America in Minneapolis Minnesota on September 25-27, 2013.

2. Task 2 – Assessing Primary Dust Exposure

a. Planned Activities

The locations for dust exposures are compiled. Those currently identified are being evaluated to find the highest/hazardous exposure rates. This process focuses where pilot analysis of actual dust exposure will take place.

Appropriate monitoring equipment is being investigated for the pilot study. Approvals for human subjects and procedures have begun.

b. Actual Accomplishments

Primary locations for dust exposure measurement will be in seedbed preparation and harvesting operations. Literature review indicates very little published research on respirable dust in agricultural operations, however it clearly indicates these operations are the most likely to have respirable 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. These will collect total dust sample and respirable dust. Exact details of the subject and plot location are still being considered, prior to 2014 fieldwork.

c. Explanation of Variance

No variance has been experienced and accomplishments are on schedule.

d. Plans for Next Quarter

Data for priority or first few sample sites will be identified during field operations.

e. Publications, Presentations, and Proposals Submitted

A poster on identification of potential sources for dust exposures of farmers engaged in biomass production was presented at the CenUSA annual meeting West Lafayette, Indiana (August 2013).

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 3. Perennial Grass Harvest Management**
  - ✓ Complete internal review of windrowing and baling lessons.
  - ✓ Submit mower-conditioning lesson for publication.
  - ✓ Make content for first three lessons available on E-Library page.
- **Module 4. Storage Management** (lead authors Pat Murphy and Iman Beheshti Tabar)

  Continue module development activities with CenUSA Extension and Outreach collaborator Amy Kohmetscher.
- **Module 5. Integrating Bioenergy Production into Current Systems**

  Complete internal review and make any necessary corrections and revisions.
- **Module 6. Balancing Energy Demand with Food, Feed and Fiber Needs**

  Complete module development activities with Amy Kohmetscher and submit 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 Guretzky class at UNL (develop quiz questions).

2. **Actual Accomplishments**

- **Module 3. Perennial Grass Harvest Management**. (Lead authors Pat Murphy, CenUSA CoPd and Iman Beheshti Tabar) status of components:
  - ✓ Kevin Shinners (UW) completed the internal review of the windrowing lesson; revisions are being made.
- **Module 4. Storage Management.** (Lead author Pat Murphy) status of components:
  - ✓ Continued module development activities.
- **Module 5. Integrating Bioenergy Production into Current Systems**. **(**Lead author Nicole Olynk Widmar) status of components:
  - ✓ CenUSA collaborator Chad Hart (ISU) completed the internal review and a process to make necessary revisions to Camtasia lectures has been determined.
- **Module 6. Balancing Energy Demand with Food, Feed and Fiber Needs** (lead author Nicole Olynk Widmar) status of components:
  - ✓ Module development activities completed.
- **Module 7. Developing a New Supply Chain for Biofuels: Contracting for Dedicated Bioenergy Crops** (lead author Corinne Alexander) status of components:
  - ✓ Module development activities completed.
  - ✓ Internal review completed by CenUSA Co-Pd Keri Jacobs (ISU) and revisions to the module will be completed in early 2014.
- **Module 8. Biofuels Policy: How Does Policy Affect the Market for Biofuels?** (lead author Corinne Alexander) status of components:
  - ✓ Draft of module content completed in PowerPoint.
  - ✓ Recording of Camtasia lectures will begin in early 2014.
- **Module 9. Enterprise Budgeting**
  - ✓ A rough draft of module was completed using content cut from the initial content drafts of the other marketing/economics modules.

- **Module 10. Title to be Determined – Initial Feedstock Development Module** (lead author Chaein Na and John Guretzky)
  - ✓ Develop outline of module content for feedstock breeding and selection module(s).
- **Evaluation tasks**
  - ✓ Evaluation data sets from content delivered to UNL and Purdue students have been putted together for analysis by CenUSA collaborator Gwen Nugent.

3. Explanation of Variance

None to report.

4. Plans for Next Quarter

- **Module 5. Integrating Bioenergy Production into Current Systems**
  - ✓ Rerecord portions of the Camtasia lectures that need to be revised.
- **Module 6. Balancing Energy Demand with Food, Feed and Fiber Needs**
  - ✓ Submit for internal review.
- **Module 9. Enterprise Budget**
  - ✓ Identify a lead author to evaluate current content and begin module development activities with Amy Kohmetscher.
- **Module 10. Title to be Determined – Initial Feedstock Development Module** (lead author Chaein Na and John Guretzky)
  - ✓ Complete outline of module content and begin module development activities with Amy Kohmetscher.
- **Evaluation Tasks**
  - ✓ Complete analysis of evaluation data sets from UNL and Purdue (Gwen Nugent).
  - ✓ Complete evaluation of content delivered to students at UNL and UIUC.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Subtask 2A: Training Undergraduates via Internship Program

1. **Planned Activities**

- On August 1, 2013 the four students placed at partner institutions (University of Minnesota, University of Nebraska, Lincoln, and the Idaho National Labs) will 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 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.
- On August 3, 2013 all student interns depart Iowa State University.
- Finalize and process all payments related to the internship program.
- Create a calendar and content outline for the summer 2014 program.

2. **Actual Accomplishments**

- The nine undergraduate student interns at partner institutions (University of Minnesota, University of Nebraska, Lincoln, and the Idaho National Labs) all returned to Iowa State on Sunday, July 28, 2013.
- On Monday, July 29, 2013 all nine student interns travel via CIT Charter Bus to Purdue University for participation in the CenUSA Annual Meeting. Students present their posters at the annual meeting on Wednesday, July 31 2013.
- All nine students travel from Purdue to Iowa State University on August 1 in preparation of the program close on August 2, 2013.
- On August 2, 2013 all student interns and some faculty mentors and graduate student mentors attend a celebration brunch at the Iowa State University's Memorial Union.
- On August 2, 2013 all nine interns participated in the ISU university-wide undergraduate research poster session and reception.

- Interns completed post-program survey and participated in focus groups conducted by Iowa State University's Research Institute for Studies in Education (RISE).
- All nine interns depart Iowa State University for home on Saturday, August 3 2013.
- All internship-relevant payments processed.
- Created tentative calendar and program content outline for the 2014 program.
- Begin soliciting faculty hosts for the summer 2014 program.

3. Explanation of Variance

None to report.

4. Plans for Next Quarter

- Finish solicitation of projects from faculty.
- Determine distribution of students to sites (number of slots for each participating lab).
- Review program assessment provided by Iowa State University's Research Institute for Studies in Education (RISE).
- 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, and by communication with Agronomy and Engineering department chairs at partner institutions.
- Migrate program website to primary CenUSA host, rather than independent site (Iowa State University's Agricultural and Biosystems Engineering Department's website) used for the program years of 2012 and 2013.

5. Publications, Presentations, and Proposals Submitted

None to report this period.

Subtask 2B – Training Graduate Students via Intensive Program

1. Planned Activities

None. This is a PY4 activity, and forward planning will begin in summer 2014.

2. Actual Accomplishments

N/A

3. **Explanation of Variance**

   N/A

4. **Plans for Next Quarter**

   N/A

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 three research webinars.
     - ✓ System Performance Metrics, Data Collection, Modeling, Analysis, and Tools Objective – September 27.
     - ✓ Feedstock Conversion/Refining Objective – October 25.
     - ✓ Markets and Distribution Objective – November 22.

2. **Actual Accomplishments**

   - System Performance Metrics, Data Collection, Modeling, Analysis, and Tools Objective research webinar on September 27, 2013 – *Sustainable Production and Distribution of Biomass for the Central US* by Jason Hill.
   - Feedstock Conversion/Refining Objective research webinar on October 25, 2013 – *Analysis for Pyrolysis Based Biofuels* by Robert Brown and Chamila Thilakaratne.

3. **Explanation of Variance**

   - Postponed the Objective 6 webinar until January 2014 due to schedule conflicts of objective leaders and graduate student presenters.

4. **Plans for Next Quarter**

   - Organize and deliver research webinars:
     - ✓ January 31, 2014 – Markets and Distribution Objective.
     - ✓ February 28, 2014 – Health and Safety Objective.

5. Publications, Presentations, and Proposals Submitted

None to report

Objective 9. Extension and Outreach

The Outreach and Extension Objective 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, with special emphasis on materials development (videos, publications, web posts, etc.).

- **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

- ✓ Complete *Switchgrass Stand Establishment: Key Factors for Success* Fact Sheet.
- ✓ Prepare final paper *Reducing Hypoxia in the Gulf: An alternative Approach* (working title) for submission as essay in professional journal.
- ✓ Prepare script, identify interviews and begin filming for video *Reducing Hypoxia in the Gulf: An Alternative Approach*.
- ✓ Begin planning for National Extension, Energy and Environment Conference, September 23-25, 2014 in Ames, IA.
- ✓ Begin development of CenUSA image collection on eXtension Farm Energy media site.
- ✓ Continue work on developing CenUSA publications for eXtension.

b. Actual Accomplishments

- ✓ CenUSA collaborator and University of Illinois –Champaign professor D.K. Lee presented the webinar *Diversifying Cellulosic Feedstocks with Native Perennial Grasses* as part of CenUSA Extension team member John Hay's **Bioenergy Friday** series (September 27, 2013). Dr. Lee discussed his perennial grass breeding efforts including his improvement in Prairie Cordgrass.

- ✓ The CenUSA perennial grass entomology video has been reviewed and is in the final editing stages. Final filming in response to the reviewer's suggestions is scheduled for November 2013.
- ✓ A script for the plant pathology video narration has been developed.
- ✓ Footage for the environmental impact video was gathered at the *Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops* workshop (September 2013).
- ✓ Two fact sheets have been updated, formatted and are in final review
    - o *Switchgrass for Biofuel Production* (Mitchell, Vogel, and Schmer).
    - o *Switchgrass Stand Establishment Key Factors for Success*.
- ✓ The paper, *Reducing Hypoxia in the Gulf: An Alternative Approach* is now in final review.
- ✓ Prepared e-FLYER *Perennial Grass Establishment for Biomass Production* and assisted with Dr. Kevin Shinners/Dr. Rob Mitchell Field Day in Evansville, Wisconsin on September 19, 2013.
- ✓ Completed interviews and filming for video *Reducing Hypoxia in the Gulf: An Alternative Approach*.
- ✓ Attended and conducted video interviews at joint CenUSA and Hypoxia Task Force meeting: *Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops*, September 23-24 in Minneapolis, MN.
- ✓ Uploaded over 50 CenUSA images showing switchgrass, other feedstocks, and field tour participants into eXtension Farm Energy Media site: http://farmenergymedia.extension.org/images.
- ✓ Met with representatives from all Bioenergy CAPS on October 11-22, 2013 to develop a system for collaborating across CAPS and plan indexing on eXtension.org for all Bioenergy CAP resource publications together.
- ✓ Maintained Published Index: Resources from CenUSA at http://www.extension.org/pages/68136 to include recently published CenUSA resources, those hosted on eXtension.org, CenUSA Site, and others.
- ✓ Continued work on articles listed below which will be published on eXtension.org:

- *Plant Breeders Create New and Better Switchgrass Varieties for Biofuels* (Casler, Harlow). The article has been reviewed and final edits are being made.
- *Research Finds Strong Genetic Diversity in Switchgrass Gene Pools – Research Summary* (Casler, Harlow). The article has been reviewed and final edits are being made.
- *Harvest and Storage of Two Perennial Grasses as Biomass Feedstocks* (Casler, Shinners, Harlow). The article is currently being drafted.
- *Control Weeds in Switchgrass (Panicum Virgatum L.)* Grown for Biomass.
- *How to Successfully Harvest Switchgrass Grown for Biofuel.*

✓ Continued to monitor impact of CenUSA Vimeo Channel: During this quarter, the 29 CenUSA videos archived on Vimeo have had 193 plays, and 4,825 loads (2,511 of the loads came from CenUSA videos being embedded on other sites), and downloaded 9 times (user download 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).

✓ CenUSA videos are also posted on YouTube and have been viewed 3,948 times as of October 31, 2013. This is the total number of views since videos were posted, not necessarily just for this quarter.

c. Explanation of Variance

✓ The entomology video was delayed because the content expert had a busy travel schedule. Final filming will be wrapped up in November, 2013.

✓ The webinar related to economics has been postponed because the desired speaker would not have findings to present until February 2014.

✓ Updating and review of papers took longer than we anticipated, as we needed USDA-ARS approval for updated fact sheets.

✓ The field day originally planned for June 2013 was cancelled due to difficult spring and poor-looking stand. The stand improved over the summer and Dr. Shinners decided to re-schedule the field day for September 19, 2013.

d. Plans for Next Quarter.

✓ Finish the entomology video.

✓ Produce a first cut of the plant pathology video.

- ✓ Organize webinars for February and March of 2014.
- ✓ Prepare the *Fact Sheet: Reducing Hypoxia in the Gulf: An Alternative Approach*. This will be a short version of the longer paper *Reducing Hypoxia in the Gulf: An Alternative Approach* produced specifically for extension and outreach audiences.
- ✓ Edit and publish the video: *Reducing Hypoxia in the Gulf: An Alternative Approach*.
- ✓ Continue assistance with planning for the *National Extension, Energy and Environment Conference* to be held September 23-25, 2014.
- ✓ Prepare plan for expanded outreach and communication using social media channels.
    - Launch a CenUSA monthly e-newsletter.
- ✓ Publish articles noted above that are nearing completion.
- ✓ Continue maintenance of index: Resources from CenUSA: Sustainable production and Distribution of Bioenergy for the Central USA.
- ✓ Setup eXtension Ask an Expert system to answer questions on CenUSA topics.
- ✓ Begin development of *Economics of Bioenergy Fact Sheet*.

e. Publications, Presentations, Proposals Submitted

See above.

2. Producer Research Plots/Perennial Grass Team

a. Planned Activities

- ✓ Minnesota: Collect yield and plant composition data.
- ✓ Nebraska: collect yield and leaf height in August, September and October 2013.
- ✓ Iowa: host field day at demonstration site at SE ISU Research and Demonstration Farm.
- ✓ Indiana: host field day at Purdue Throckmorton Ag Center.

b. Actual Accomplishments

- ✓ **Iowa**.
    - Conducted a field day at the CenUSA demonstration plot at the ISU *SE Research and Demonstration Farm* on September 12, 2013 (39 participants).

- ✓ **Nebraska**.
  - On August 5, 2013 we collected biomass, visual observation and leaf height data at the Humboldt, Nebraska site.
  - On September 5, 2013 we collected biomass, visual observation and leaf height data at the Humboldt, Nebraska site.
  - On October 31, 2013 we collected biomass, visual observation and leaf height data at the Humboldt, Nebraska site. We also made arrangements to a hire custom hay cutter to remove biomass from entire plot prior to winter setting in.

Photo 2. field day at Purdue's Throckmorton Ag Center on Oct. 15, 2013

- ✓ **Indiana**.

- We conducted a field day at Purdue's Throckmorton Ag Center on Oct. 15, 2013. 55 people attended (35 male, 20 female, 2 African-American, 3 Asian).[5]

Table 12. Throckmorton Ag Center Field Day Evaluation (n=55)				
			Yes	No
Had you heard about specific environmental implications of bioenergy grass production before today?			76	24
	Not at all	Little	Some	A lot
How did the discussion about bioenergy grasses (switchgrass, miscanthus, sorghum) influence your choice of species for bioenergy production?	10	19	52	19
How easy was it to recognize how genetic improve?		14	29	57

✓ **Minnesota**

- The plots have finally been established at two locations (Elko, MN and Lamberton, MN) after several weather disasters over the past two springs.
- We worked with a high school student at the Elko site to use some of the border areas of the demonstration for a high school science project. The objective is to evaluate use of biochar as a soil amendment for biofuel crops. Treatments were established this summer and soil and tissue samples are being collected this fall.

c. Explanation of Variance

Minnesota: Rather than use a farmer site for the Lamberton demonstration plot, we used the Southwest Research and Outreach Center because of better outreach opportunities at the center due to planned field days next year.

d. Plans for Next Quarter

✓ Indiana: We will harvest and analyze samples from the three Indiana demonstrations.

✓ Iowa: We will harvest samples from plots in Johnson and Washington County.

✓ Minnesota: We will analyze data collected for the plots and begin planning for CenUSA annual meeting next summer in Minnesota.

[5] Photos from the event are available at www.facebook.com/media/set/?set=a.437256803046707.1073741827.119556214816769&type=1&l=8c9e314a16

- ✓ Nebraska: We will confirm biomass was removed from the entire plot area by custom hay cutter.

e. Publications, Presentations, Proposals Submitted

None.

3. Economics and Decision Tools

a. Indiana

- ✓ **Planned Activities**

Host Bioenergy Grass Field Day on Oct. 15, 2013.

- ✓ **Actual Accomplishments**
  - Hosted Purdue Bioenergy Grass Field Day on Oct. 15, 2013. Fifty-five people attended (35 male, 20 female). See Table 12 for evaluation results.

- ✓ **Explanation of Variance**

None.

- ✓ **Plans for Next Quarter**

Conduct professional development session for Purdue Extension Educators (November 6, 2013).

- ✓ Publications, Presentations, Proposals Submitted

b. Iowa

- ✓ **Plans for Next Quarter**

Host CenUSA sessions at the 2013 Iowa Integrated Crop Management Conference.

c. Minnesota

- ✓ **Planned Activities**

Hold a webinar on September 30, 2013 on the CenUSA nitrogen spreadsheet for 130 Soil and Water Conservation Society and Minnesota Pollution Control Agency staff.

- ✓ **Actual Accomplishments**

- Webinar on September 30, 2013 on the CenUSA nitrogen spreadsheet for 130 Soil and Water Conservation Society and Minnesota Pollution Control Agency staff.
- Continued making improvements to the spreadsheet; learned the basics of ArcGIS and made five maps of the key results by HUC8 watershed and uploaded them to Lazarus website: http://faculty.apec.umn.edu/wlazarus/interests-water.html.

✓ **Explanation of Variance**

We did not experience any variance from our expected plans.

✓ **Plans for Next Quarter**

Presentations planned on the nitrogen spreadsheet to the Minnesota Association of Soil and Water Conservation Districts on December 2, 2013.

✓ **Publications, Presentations, Proposals Submitted**

Spreadsheet model (See above).

4. Health and Safety

See Health and Safety Objective report, above.

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

a. Indiana

✓ **Planned Activities – Youth Development**

- Create a career component for the static CenUSA exhibit.
- Utilize the CenUSA exhibit 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 online modules.

✓ **Actual Accomplishments – Youth Development**

- Career component initiated and piloted at Indiana State Fair for Purdue CenUSA display.
- CenUSA display staged at Indiana State Fair 2013 for 10 days. An estimated 10,000 youth viewed the exhibit.
- Online module software licensing obtained and continuation of online module building is in process.
- Lessons (curriculum) for youth are in editing and revision phase.
- Collaboration with FFA, Chad Martin and Keith Johnson is in initial phase.

✓ **Explanation of Variance**

- Items not completed are in progress and were expected to carry over to the next quarter(s):

  Provide training for school garden programming for elementary and high school; plan and implement school garden program

✓ **Plans for Next Quarter**

- Plan 4-H Science Workshops.
- Complete career component for display; utilize display with at 4-H/FFA event in December.
- Host meetings with Ag teachers and Extension Educators to review curriculum and programming.
- Continue communications with FFA on demonstration plots.
- Continue development of online modules.
- Continue edits and revisions of curricula for 4-H, High school and gardens.

✓ **Publications, Presentations, Proposals Submitted**

See above.

b. Iowa

✓ **Planned Activities – Youth Development**

- Develop an iPad learning app to introduce youth to the element Carbon, the difference between "old" (fossil) carbon and "new" (renewable carbon).
- Pilot the app at the Iowa State Fair.
- Analyze feedback and evaluate what the participants learned from the C6 app.

✓ **Actual Accomplishments – Youth Development**

- Developed the i-Pad C6 learning app and debuted the program at the 2013 Iowa State Fair; 223 youth completed the app activity.
- We hosted a learning exhibit at Iowa STEM educators event on September 25, 2013.
- We hosted a hands-on exhibit at the ISU Order of the Knoll (event for donors to ISU).

✓ **Explanation of Variance**

No variance has been experienced and accomplishments are on schedule.

✓ **Plans for Next Quarter**

- Recruit students to continue development of the C6 learning app that focuses on potential role of perennial grasses to provide bioenergy feedstocks and environmental services for Midwest agriculture.
- Continue to take the C6 learning exhibit and game to STEM Festivals across Iowa and with 4-H clubs and University K12 outreach.

✓ **Publications, Presentations, Proposals Submitted**

See above.

3.B Broader Public Education/Master Gardener Program

a. Iowa

✓ **Planned Activities**

- Continue collecting and recording crop harvest data from biochar test plots.
- Host a Farm Home Demonstration Garden Field Day at the Horticulture Research Station in Ames on August 6, 2013.
- Host a Home Demonstration Garden Field Day on August 8, 2013 in Muscatine, Iowa.
- Develop on-line PowerPoint for Master Gardners to use as a volunteer recruitment tool for the CenUSA biochar project.

✓ **Actual Accomplishments**

- Final harvests and crop data collections were completed from the three Iowa biochar test plot sites for the 2013 season.
- We featured biochar test plots at the Farm Home Demo Garden Field Day near Ames, Iowa on August 6, 2013.
- We featured biochar test plots at the Home Demonstration Garden Field Day held on August 8, 2013 in Muscatine, Iowa. A newspaper article appeared in Muscatine Journal about the biochar test plots.
- We developed on-line information for Master Gardener volunteer recruitment for the biochar project.
- A total of 350 people participated in the Iowa Garden Tours this quarter (228 women and 122 males). Data from evaluations include showed:
    - Before the field days, 77% of respondents had low or no understanding of biochar as a byproduct, how it differed from charcoal, or the benefits and economic value of biochar as a soil amendment. Additionally, 76% of participants had low to no likeliness of finding out more about biochar, using it, or telling others about biochar.
    - After attending the field days, more than 80% of respondents reported a moderate to high understanding of biochar as a byproduct of thermochemically processing biomass to biofuels, how biochar differs from charcoal and its benefits as a soil amendment; 72% of respondents had a moderate to high understanding of the economic value of biochar; and 68% had a moderate to high likeliness of searching for more information about biochar, using it, or telling others about biochar.

✓ **Explanation of Variance**

None.

✓ **Plans for Next Quarter**

- We will meet with the CenUSA group to help with plans for the 2014 test plot gardens.
- We will complete entry of garden plot crop data into the on-line reporting system.
- We will continue work on developing on-line Master Gardener volunteer recruitment materials.

b. Minnesota

✓ **Planned Activities**

- Set up biochar display for Master Gardener exhibit at the 2013 Minnesota State Fair.
- Set up biochar exhibit for Master Gardener exhibit at the *Northern Threshing Show*.
- Maintain Biochar Demonstration Gardens on a regular basis; collect data on select plants and post online according to guidelines developed for Extension Master Gardener volunteers.
- Develop signage for use at all Iowa and Minnesota sites.

✓ **Actual Accomplishments**

- We developed a conference style pull-up banner and matching handbills featuring the research being done at the Extension Master Gardener demonstration gardens.
- Thirty-four Master Gardener volunteers maintained and collected data at the three biochar demonstration gardens in the Twin City metro area: Minnesota Landscape Arboretum, the UMN St. Paul Campus and the Bunker Hills site in Andover.
- We wrote and published a blog about the CenUSA Annual Meeting in West Lafayette, IN which can be found at: http://blogs.extension.org/mastergardener/2013/08/27/cenusa-annual-meeting-helps-extension-master-gardeners-connect-native-grass-biochar-and-biofuel-research/. (See Exhibit 9. *CenUSA Annual Meeting Helps Extension Master Gardeners Connect Native Grass, Biochar and Biofuel Research*). The biochar content overall had 245 hits/210 unique views. The blog about the annual meeting

generated 89 views and previous blogs from the Fond du Lac post received 67 views.

- Biochar exhibits were updated to reflect the new demonstration site at the Fond du Lac Native American Tribal Community; flyers were printed and new evaluation postcards were developed for each event. The biochar exhibit was displayed at the Minnesota State Fair at the Extension Master Gardener information booth and at the Nowthen Threshing Show at the Anoka County Extension Master Gardener Information Booth. At the MN State Fair, 4400 people visited the Extension Master Gardener booth and 55 people completed surveys. The Nowthen Threshing Show had over 500 visitors.
- Extension Master Gardener volunteers collected data on various crops that include plant heights, widths and color, plus yields to include count and weight. Data collection continued on various crops through the first frost.
- Plant tissue samples were collected for Kurt Spokas, Soil Scientist, USDA-ARS, who has been testing toxicity of select plants on behalf of the Extension Master Gardener biochar project.
- Demonstration gardens have been cleaned up for winter.

✓ **Explanation of Variance**

- Minnesota Extension Master Gardener volunteers ran into difficulty establishing the demonstration garden at the Fond du Lac Tribal Community Center. There will be very little data coming from that garden for the 2013 report.

✓ **Plans for Next Quarter**

- We will conduct soil tests on the three metro area demonstration garden sites.
- We will develop the 2013 Biochar Demonstration Garden Report based on the data that was submitted by Extension Master Gardeners.
- We will complete the final design for more interpretive signage that will be used at the 2014 demonstration garden sites.

✓ **Broader Public Education/Master Gardener Program - Publications, Presentations, Proposals Submitted**

- CenUSA Annual Meeting Helps Extension Master Gardeners Connect Native Grass, Biochar and Biofuel Research (See Exhibit 7. *CenUSA Annual Meeting Helps Extension Master Gardeners Connect Native Grass, Biochar and Biofuel*

Research). http://blogs.extension.org/mastergardener/2013/08/27/cenusa-annual-meeting-helps-extension-master-gardeners-connect-native-grass-biochar-and-biofuel-research/

- Analytics report from blog posts.
- Fact Sheet *Iowa Increases Public's Knowledge About Biomass*.

6. Evaluation and Administration

a. Planned Activities

- ✓ Host joint conference with Hypoxia Task Force in September 2013.
- ✓ Attend 2013 *Extension Galaxy Conference* to exhibit and host session about CenUSA.
- ✓ Attend *Food, Fuel & Fiber* conference in Illinois to begin planning and market the *CenUSA Extension Energy and Environment* conference in 2014.
- ✓ Recruit people to serve on the planning committee for 2014 *Extension Energy and Environment* conference.
- ✓ Develop evaluation instruments for use by CenUSA Extension faculty and staff.

b. Actual Accomplishments

- ✓ We hosted the *Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops* workshop in September. Evaluation of the conference showed:
  - Before, 42% had None-Low knowledge of growing perennial grasses to lower nutrient runoff. After, 96% had Mod-High knowledge.
  - Before, 49% had None-Low knowledge regarding opportunities to develop market for perennial grasses grown for biofuel production. After, 77% had Mod-High knowledge.
  - Before, 52% had None-Low knowledge of the economic drivers for growing perennial grasses for biofuel production. After, 89% had Mod-High knowledge.
  - Before, 50% had None-Low knowledge of the value of including incentives to grow perennial grasses in state nutrient reduction plans. After, 80% had Mod-High knowledge.

- ✓ We exhibited and presented at the *Extension Galaxy Conference* in Pittsburg, Pennsylvania. We shared information with more than 1000 Extension Educators at the CenUSA exhibit.
- ✓ We participated in the Illinois *Food, Fuel & Fiber* conference to market the 2014 *CenUSA Extension Energy and Environment* conference.
- ✓ We developed a feedback business-reply postcard to distribute at events where conducting a traditional survey is not feasible. The piece was used at:
  - Used at the Minnesota horticulture field days.
  - Used at the Minnesota State Fair.
- ✓ We developed a survey for the Minnesota Master Gardeners biochar training webinar.
- ✓ We wrote a report on Iowa State horticulture biochar survey results (*Iowa Increases Knowledge about Biomass* (See Exhibit 10).
- ✓ We provided evaluation assistance to the CenUSA Sustainable Bioenergy Workgroup.
- ✓ We participated in the *Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops* workshop held in conjunction with state and federal agencies involved in nutrient reduction from agricultural production; we summarized the evaluation results from the conference (see above).
- ✓ We developed a feedback postcard for Purdue University Bioenergy Grass Field Tour.
- ✓ We contributed to journal article for *Biofuels Future Science* on CenUSA outreach efforts.
- ✓ We presented CenUSA Extension & Outreach summary at a national conference with the American Association of Industrial Crops and NIFA.

c. Explanation of Variance

None

d. Plans for Next Quarter

- ✓ We will continue planning for the 2014 *Extension Energy and Environment conference*.

- ✓ We will develop evaluation instruments for IA CenUSA sessions at the 2013 *Integrated Crop Management* conference.

e. Publications, Presentations, Proposals Submitted

See above.

Exhibit 1

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 2

CenUSA Bioenergy
Iowa State University Project Participants

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Exhibit 3

CenUSA Annual Meeting: Field Tour Agenda

July 31st, 2013

Purdue University,

West Lafayette, IN

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ACKNOWLEDGMENTS

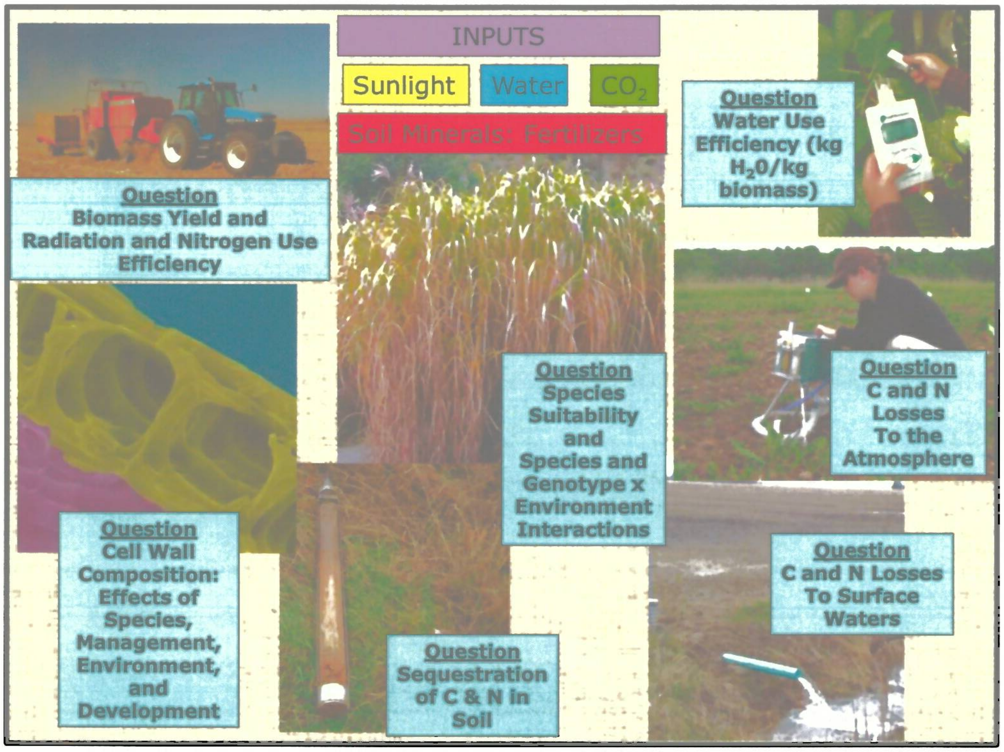
The CenUSA Bioenergy project is supported by Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30411 from the USDA National Institute of Food and Agriculture.

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 9:10	Field Presentation: Sylvie Brouder	3 to 4
9:10 to 9:35	Field Presentation: Mary-Jane Orr	5 to 6
9:35 to 10:00	Field Presentation: Elizabeth Trybula	7 to 8
10:00 to 10:25	Transport to Agronomy Center for Research and Education (ACRE) Beck Center: Restroom Break	-
10:25 to 11:00	Transport to Throckmorton – Purdue Agricultural Center (TPAC)	9 to 10
11:00 to 11:15	Transport to TPAC East	-
11:15 to 11:40	Field Presentation: Amanda Montgomery	11 to 12
11:40 to 12:00	Transport to TPAC West	-
12:00 to 12:25	Field Presentation: Ryan Dierking	13 to 16
12:25 to 12:50	Field Presentation: Monique Long	17 to 18
12:50 to 1:20	Transport to ACRE Beck Center	-
1:20 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
- Purdue University Department of Agronomy
- USDA-NRI
- USDA-NIFA/AFRI
- 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

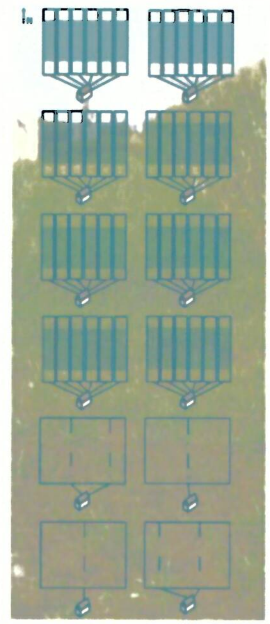
Advance the understanding of the unbreakable link between agricultural productivity and environmental stewardship. Provide an infield laboratory for studying mechanisms & processes governing productivity & environmental impacts of management technologies (e.g. ag, chemicals, nutrients, manure constituents)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

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

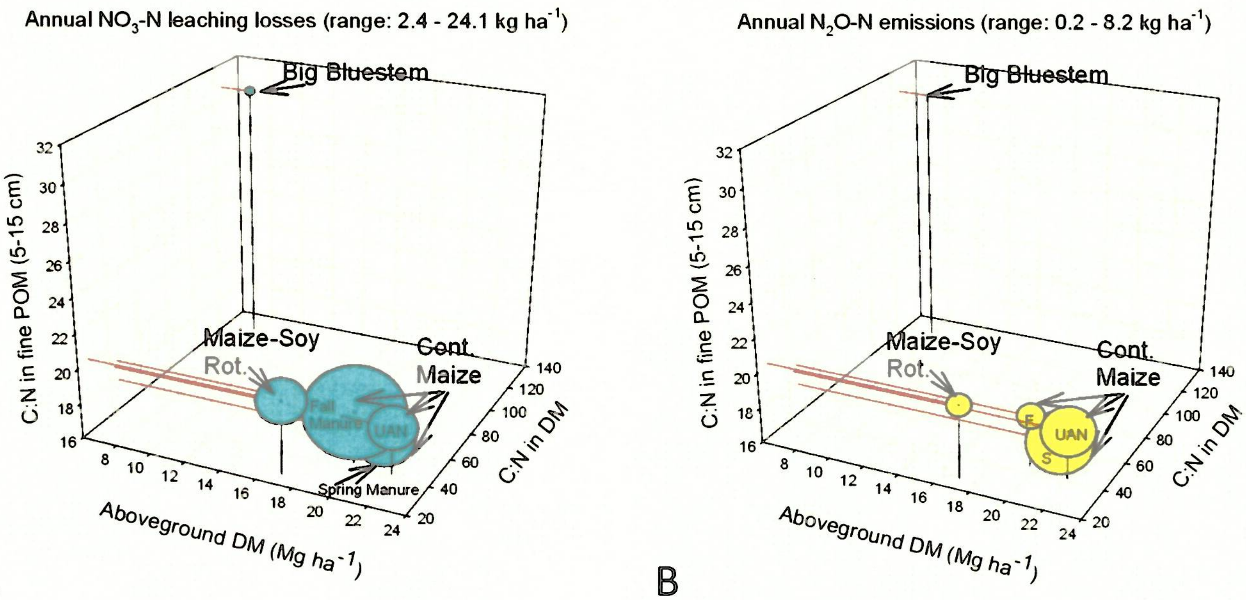


Fig.1. *Annual nitrate-N leaching losses (A) and nitrous oxide-N emissions (B) plotted as a function of total aboveground dry matter (maximum biomass), C:N ratio in the aboveground dry matter, & C:N ratio in the fine particulate organic matter in soil. The size of the bubble indicates the relative magnitude 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

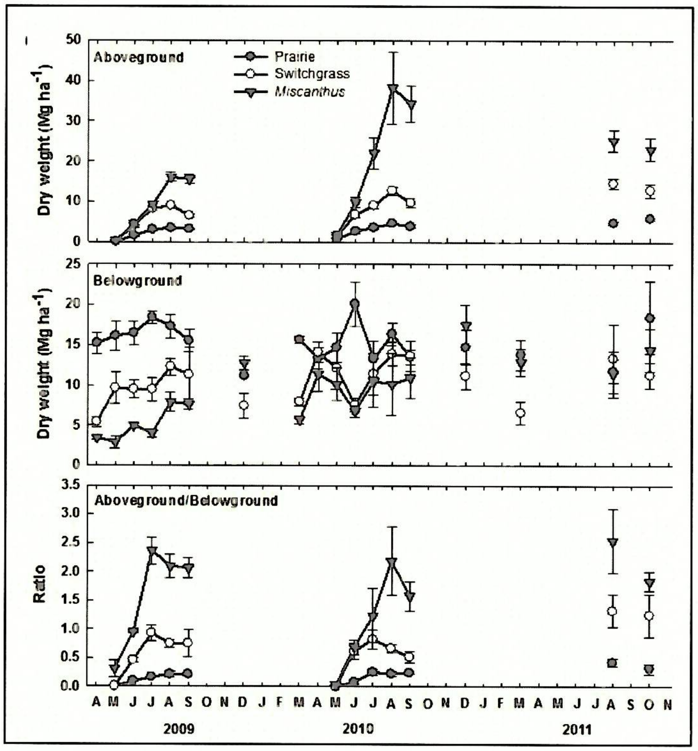
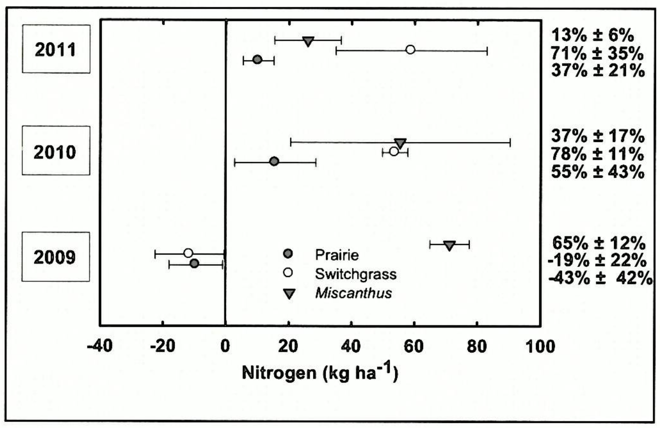


Fig.1.right. *Aboveground biomass yield ranks in order: Miscanthus > switchgrass>prairie. Comparatively, prairie produces the greatest belowground biomass; within 4 yrs of establishment, we observed very low root mass in Miscanthus. This species partitions relatively more biomass aboveground than the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

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

Mary-Jane Orr, M. Bischoff, N. De Armond, S. Cunningham, S. Brouder, J. Volenec, and R. Turco

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 to 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

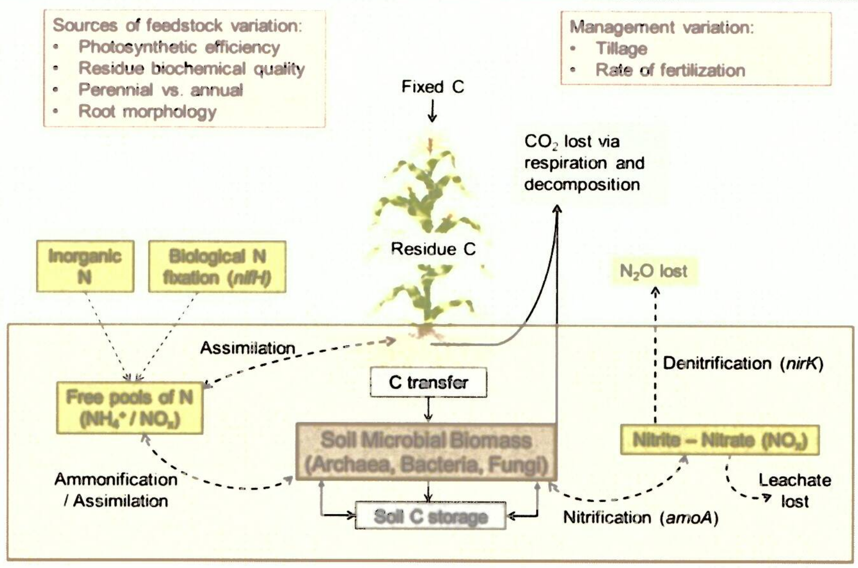

Fig.1. *Schematic of targeted N and C transformations*

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*

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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

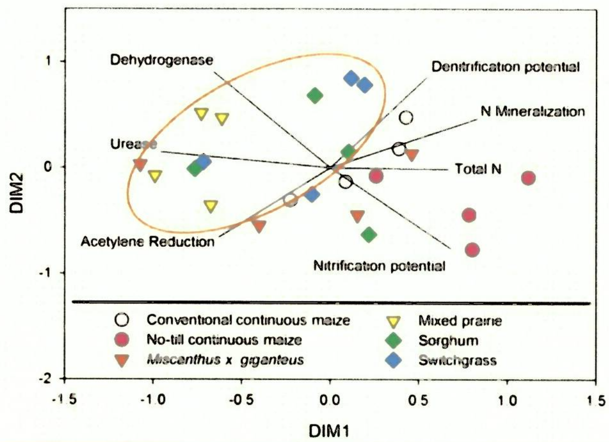

Fig.3. *Biplot representation of Principal Component Analysis (PCA) of N cycling measures. Total variance explained 63.2%; PC1(39.7%):PC2(23.5%). Clustering of field replicates illustrates separation along x-axis of cropping systems following 2-years of establishment at WQFS field site (2011). Circle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

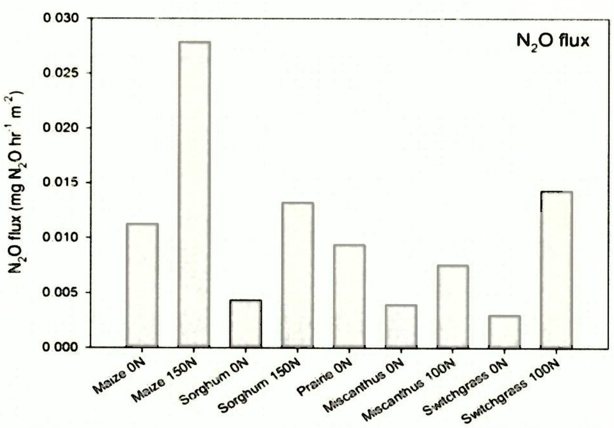

Fig.4. *Baseline GHG emissions of N_2O from a subset of the Factor Analysis Plots at the TPAC field site. Figure presents data averaged over weekly measures taken April 22 to May 7, 2013 prior to field activities. Pattern of enhanced N_2O flux with N additions in both annual and perennial systems, however 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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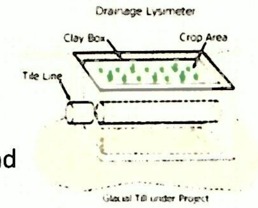
ECOHYDROLOGIC IMPACTS OF PERENNIAL PHIZOMATOUS GASSES ON TILE DISCHARGE AT THE PURDUE UNIVERSITY WATER QUALITY FIELD STATION

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

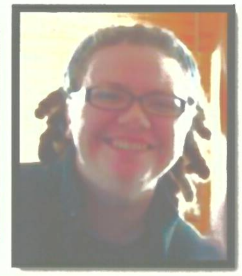
Tile Drain Flow Event Volume

- *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

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

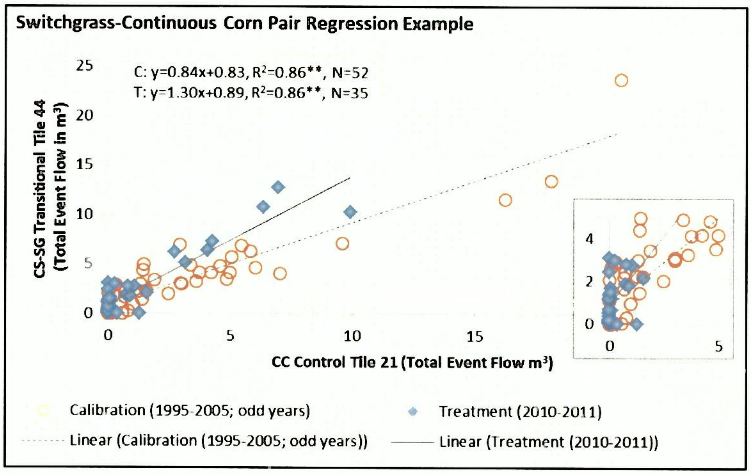


***Figure above**: replicate demonstrates significant increase in tile drain event volume due to establishment of switchgrass.*
***Paired relationship ANOVA significant at p=0.00*

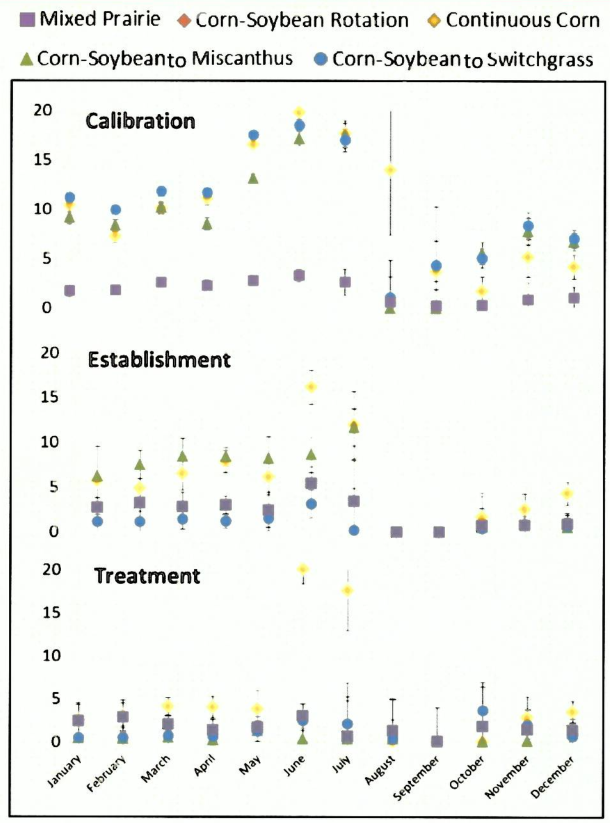
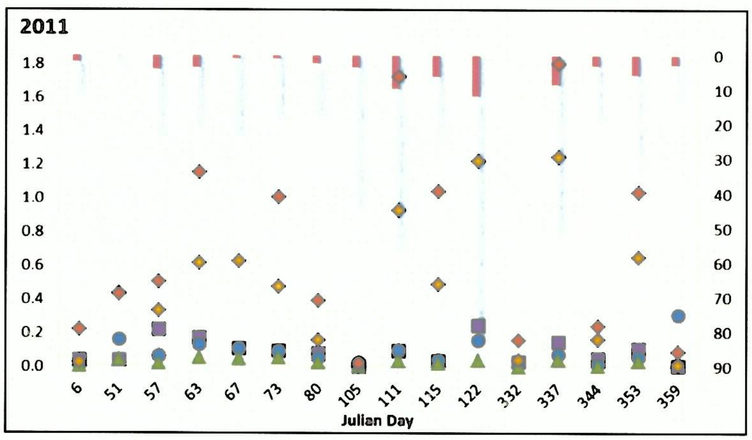


***Figure above:** average monthly tile drain nitrate concentration by cropping system. Establishment of Miscanthus and switchgrass decreased nitrate concentrations to values observed in long-term mixed prairie plots within three years.*
***Figure right:** cropping system nitrate load with respect to 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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cenusa bioenergy

PURDUE UNIVERSITY

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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Lafayette, IN 47909-9049
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TPAC

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.

07/12

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.

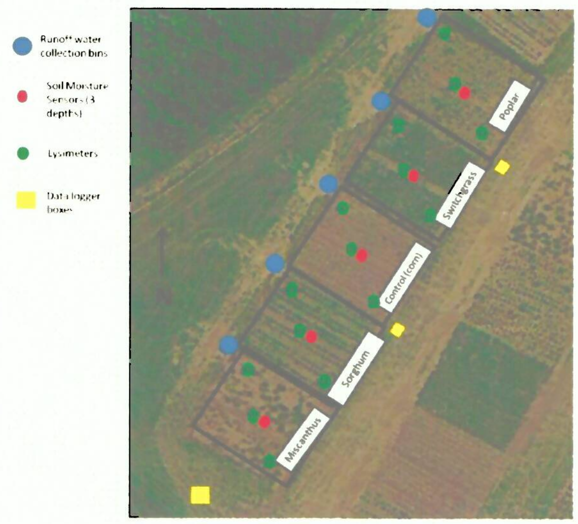
2) Explore the interaction among climate variability, hydrology, water quality and the growth of various biofuel crops to quantify long-term sustainability.

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

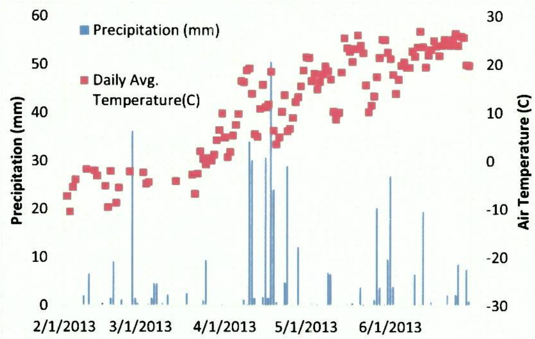

Fig.1. *Daily precipitation and*

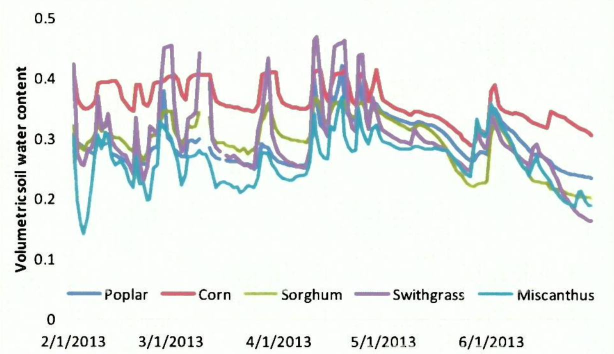

Fig.2. *Soil moisture at a depth of 30*

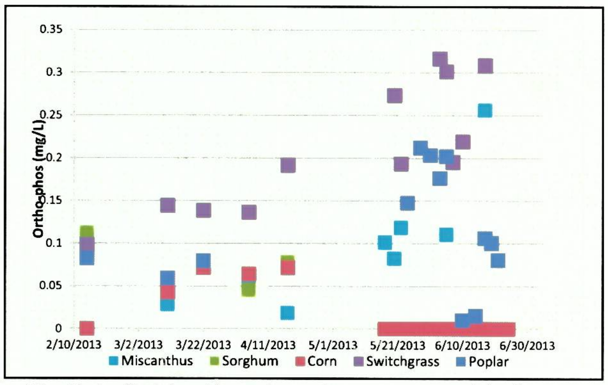

Fig.3. *In field ortho-phosphorus, central lysimeter*

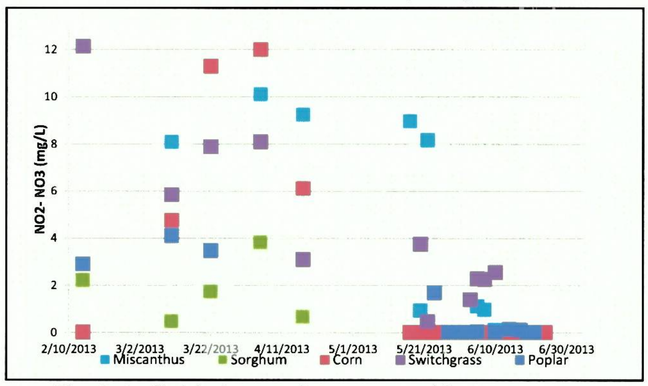

Fig.4. *In field nitrate data, central lysimeter*

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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Ruoyu Wang: wang1283@purdue.edu

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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

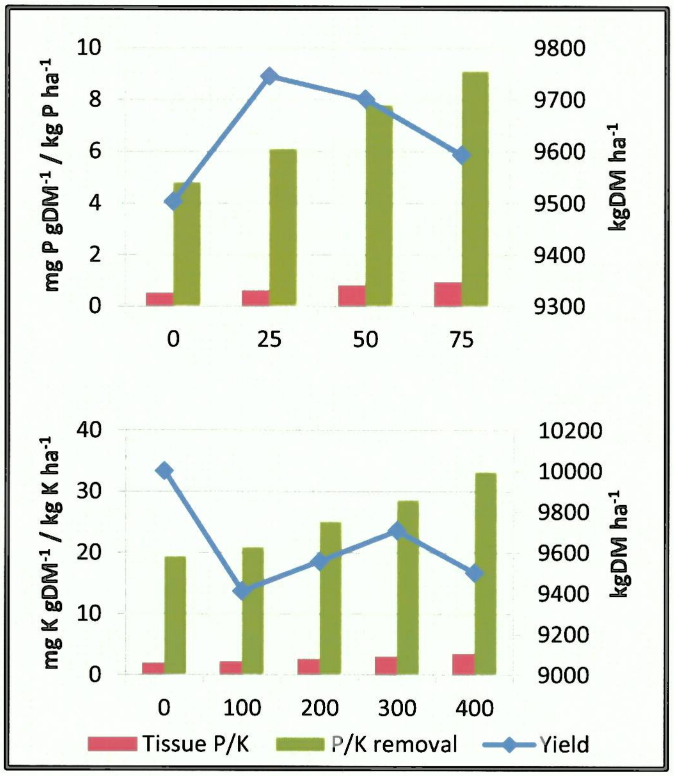

Fig.1. *Yield responses (line), P/K tissue (red bar), and P/K removal (green bar) for TPAC I historical*

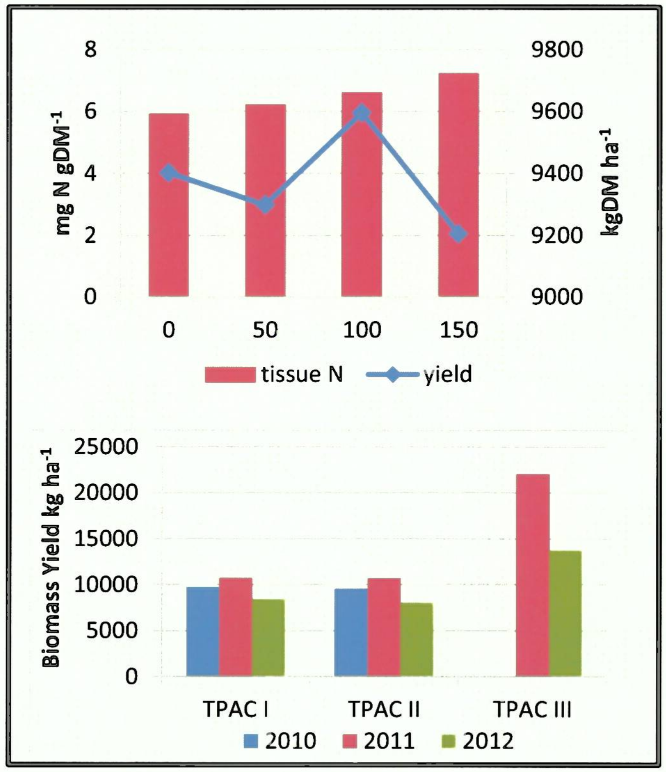

Fig.2. *Yield responses (line), N tissue (red bar) for TPAC II (top). Yield changes across years (bottom)*

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.

CONTACT INFORMATION

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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

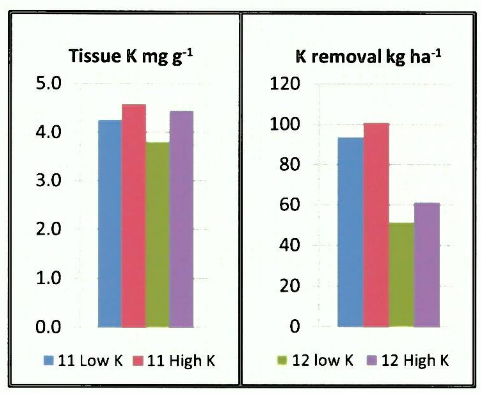
- Identify cultural practices necessary to maintain soil fertility and high production biomass.
- Ascertain the range of components (i.e. fiber and minerals) and their impact on ethanol or bio-oil generation.

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

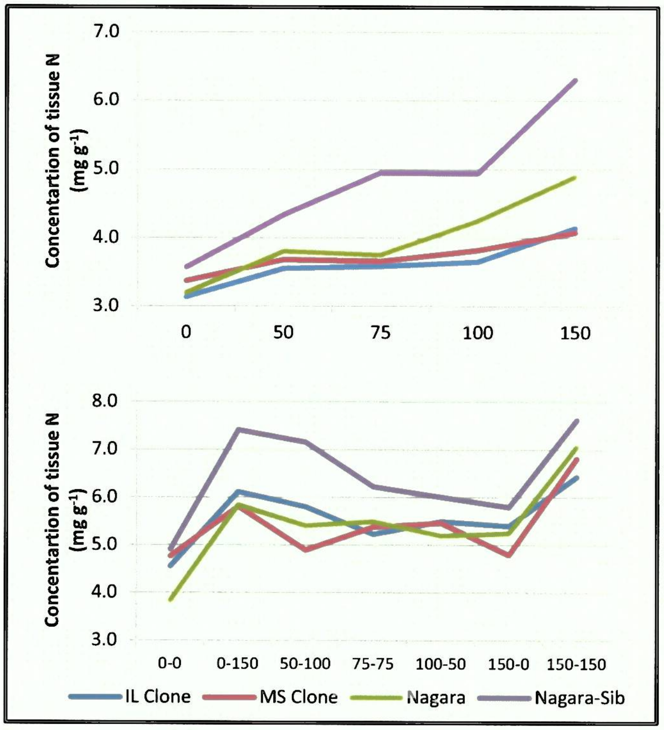


Fig.1. *Concentration of tissue N in four genotypes of Miscanthus in 2011 (top) and 2012 (bottom) with varying levels of N-fertilization.*

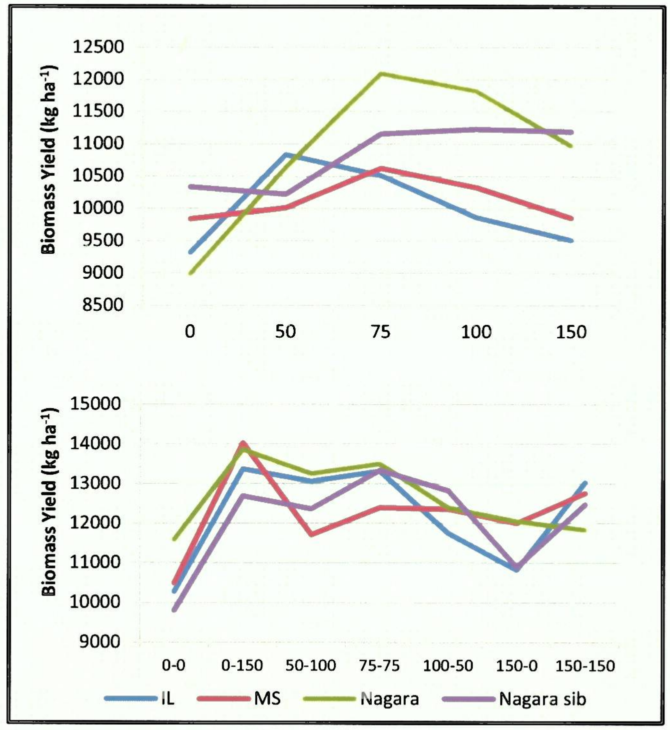


Fig.2. *Biomass yield of four genotypes of Miscanthus in 2011 (top) and 2012 (bottom) with varying levels of N-fertilization.*

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

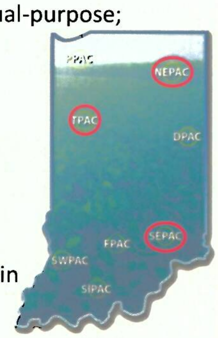

Fig 1. Purdue Marginal Sites

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).

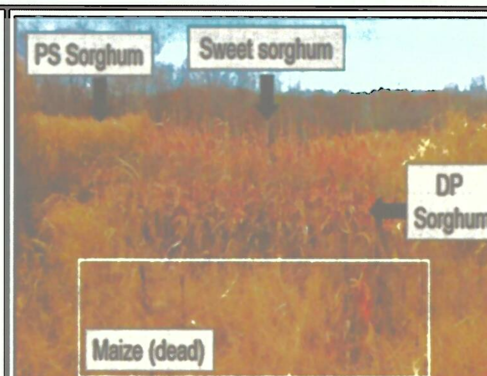

Fig 2. SePAC 2012 at time of harvest

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

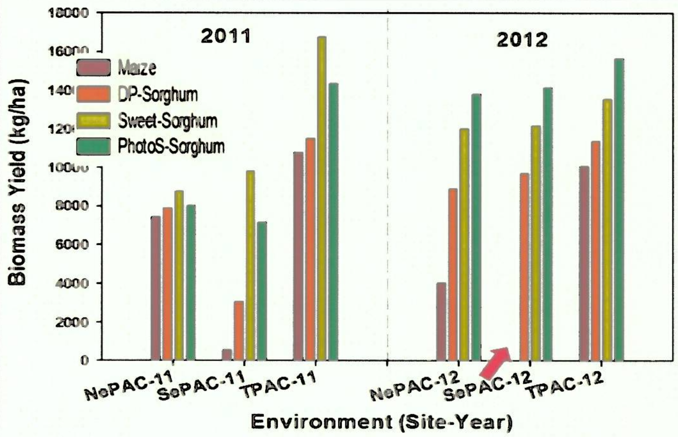

Fig 3. *In 2011-12 sorghum yields were higher than maize on marginal lands. At SePAC' 12, all 3 sorghum genotypes had average yields; maize produced none (arrow).*

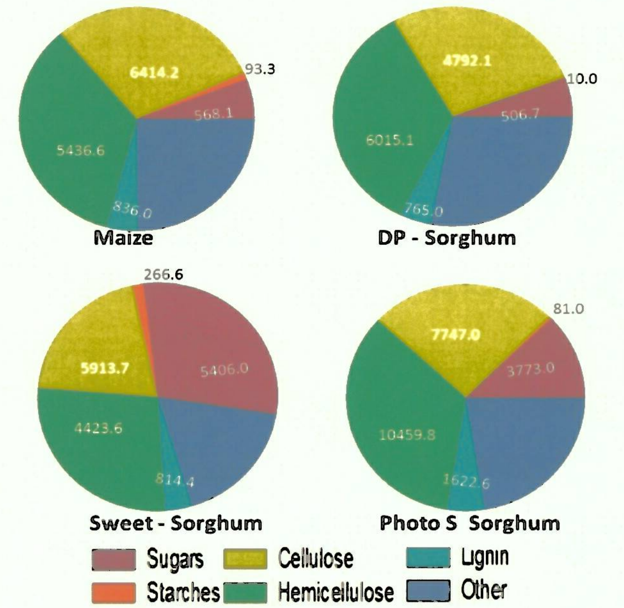

Fig 4. *In 2008 ACRE, the stover tissue composition is similar in maize (top-L), dual purpose sorghum (top-R), but is different among Photo S sorghum (right) and sweet sorghum (bottom-L) genotypes.*

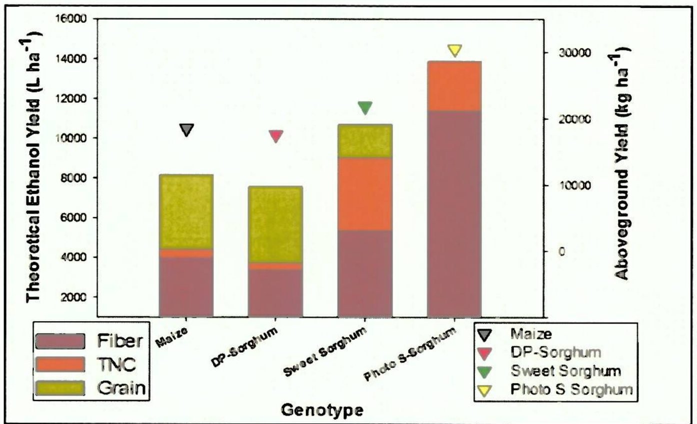

Fig 5. *In 2008 the calculated theoretical ethanol yields demonstrate that variation in biomass composition will impact ethanol yield per ha.*

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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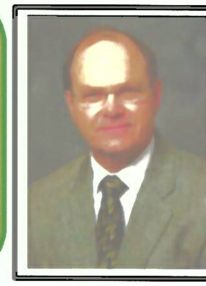
EVALUATING SWITCHGRASS, BIG BLUESTEM AND INDIANGRASS SELECTIONS FOR THEIR ADAPTATION, PRODUCTIVITY AND COMPOSITION

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.

CONTACT INFORMATION

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cenusa bioenergy

PURDUE UNIVERSITY

NOTES

NOTES

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UNIVERSITY

Exhibit 4

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.

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.

- 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…
- None 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

1. **Administrative support during the past year has been helpful.**
2. **Administrative responses to my questions/concerns were handled quickly.**
3. **Budget requests were handled in a timely manner.**
4. **Budget issues were resolved to my satisfaction.**
5. **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%

6. **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.

7. 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.

8. 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.

Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops

September 23–24 | Depot-Renaissance, Minneapolis, Minnesota

Exhibit 5

MONDAY, September 23, 2013*

8:00 – 8:45 am — Registration

8:45 – 9:00 am — **Welcome**
- **Jason Hill**, McKnight Land-Grant Professor, Bioproducts and Biosystems Engineering, University of Minnesota

9:00 – 9:30 am — **Keynote: Overview of the Hypoxia Task Force Goals, Obligations, and Timeline**
- **Nancy Stoner**, Acting Assistant Administrator for the Office of Water at EPA in Washington, DC and the Federal Co-Chair of the Hypoxia Task Force

9:30 – 10:30 am — **Midwest Agricultural Landscapes and Ecosystem Services: Problems and Opportunities**
- **Steve Polasky**, Fesler-Lampert Professor of Ecological/Environmental Economics, University of Minnesota, and the Natural Capital Project
- **Bonnie Keeler**, Institute on the Environment, University of Minnesota, and the Natural Capital Project
- **Craig Cox**, Senior Vice President, Agriculture and Natural Resources, Environmental Working Group
- **Ned Stowe**, Policy Associate, Environmental and Energy Study Institute

10:30 – 10:45 am — BREAK

10:45 – 11:45 am — **Farmer and Industry Perspectives: Growing Crops for Bioenergy and Ecosystem Services**
- **David Kolsrud**, President/CEO, DAK Renewable Energy
- **David Miller**, Iowa Farm Bureau Federation
- **Jamie Derr**, Farmer, Wisconsin Bioenergy Advisory Council, Wisconsin Rural Energy Management Council
- **Bill Belden**, Prairie Lands Biomass LLC

LUNCH — **Keynote: Synergies Between Nutrient Management Plans and CenUSA Vision**
- **Bill Northey**, Iowa Secretary of Agriculture and Co-Chair, Hypoxia Task Force
- **Brian Buhr**, Interim Dean, College of Food, Agriculture and Natural Resource Sciences, University of Minnesota (Introduction to Mr. Northey)

1:15 – 2:45 pm — **A Vision for Sustainable Midwest Agricultural Landscapes: Perennial Grasses for Bioenergy and Ecosystem Services**
- **Ken Moore**, Project Director, CenUSA Bioenergy
- **Cathy Kling**, Director, CARD, Iowa State University
- **May Wu**, Environmental Scientist, Argonne National Laboratory
- **David Muth**, Praxik, LLC
- **Nathanael Greene**, Director of Renewable Energy Policy, Natural Resources Defense Council

2:45 – 3:00 pm — BREAK

3:00 – 5:00 pm — **Work Group Discussions:** Develop actionable strategies to incent adoption of perennials on the landscape; Develop a list of ideas for sharing with HTF on Day 2 *(HTF Attendees-depart for meeting at McKnight)*

6:00 – 9:00 pm — **Stand up dinner and Reception at the Mill City Museum, including brief comments by**
- **Ann Bartuska**, Deputy Under Secretary for Research, Education and Economics, USDA
- **Brian Buhr**, Interim Dean, College of Food, Agriculture and Natural Resource Sciences, University of Minnesota
- **Ken Moore**, Project Director, CenUSA Bioenergy
- **John Linc Stine**, Commissioner, Minnesota Pollution Control Agency
- **John Anfinson,** Chief, Resource Management, Mississippi National River and Recreation Area, National Park Service

TUESDAY, September 24, 2013
Hypoxia Task Force Public Meeting**

8:00 **Welcome/Greetings/Agenda Overview**
- John Linc Stine, Minnesota Pollution Control Agency
- Nancy Stoner, US Environmental Protection Agency

8:15 **Overview of Progress Since Last Meeting (announcements, documents completed, outreach progress/discussions with other partners)**
- Nancy Stoner, US Environmental Protection Agency
- Bill Northey, Iowa Department of Agriculture and Land Stewardship

8:45 **Land Grant Update Since Last Meeting**
- David Shaw, Mississippi State University
- John Lawrence, Iowa State University

9:00 **Size of Hypoxic Zone in 2013**
- Rob Magnien, National Oceanic and Atmospheric Administration

9:15 **Applying Social and Economic Science to State Nutrient Strategies**
- Ken Genskow, University of Wisconsin-Madison
- Mae Davenport, University of Minnesota
- Otto Doering, Purdue University

10:00 **Break**

10:15 **The Role of Foundations in MARB Nutrient Reduction**
- Ron Kroese, McKnight Foundation
- Eric Forward, National Fish and Wildlife Foundation
- Moira Mcdonald, Walton Family Foundation

11:00 **Cover Crop Panel**
- Ryan Stockwell, National Wildlife Federation
- Tom Kaspar, USDA Agricultural Research Service, Member of Midwest Cover Crop Council
- Don Elsbernd, National Corn Growers Association

11:45 **Mississippi River Cities and Towns Initiative**
- Dave Kleis, Mayor, St. Cloud, Minnesota

12:15 Lunch (on your own)

1:15 **New USDA Policies, Approaches and Tools to Support Conservation Targeting**
- Ann Mills, USDA Natural Resources and the Environment
- Tom Christensen, USDA Natural Resources Conservation Service

1:45 **Overview of Minnesota's State Nutrient Strategy**
- Rebecca Flood, Minnesota Pollution Control Agency

2:45 **Conservation Partners Panel: America's Watershed Initiative and Conservation Technology Information Center**
- Jordy Jordahl, America's Watershed Initiative
- Karen A. Scanlon, Conservation Technology Information Center

3:30 **Public Comments Session**

4:00 **Adjourn**

**Hosted by USDA/NIFA, University of Minnesota, CenUSA Bioenergy USDA/NIFA CAP, Iowa State University Bioeconomy Institute, Center for Rural Research and Development (CARD), and Iowa EPSCoR*

*** Hosted by Hypoxia Task Force*

Exhibit 6

Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops
Conference Preliminary Report

Description

Numerous research efforts have affirmed that bioenergy can offer substantial environmental benefits manifest in ecosystem services. Recent interest in bioenergy for reducing dependence on fossil fuels therefore presents an opportunity to ameliorate negative impacts of current agroecosystems while enhancing farmer livelihoods and the public interest. For this to happen, a concerted effort is necessary on the part of farmers and agribusiness, policymakers and regulators, agricultural trade associations, environmental non-governmental organizations, and academic researchers. To this end, a workshop of approximately 100 attendees was held on September 23–24, 2013, to facilitate development of biomass production options through organization of an actionable discussion around biofuel supply chain sustainability. The workshop was held concurrently with the annual meeting of the Gulf Hypoxia Task Force. Supporting objectives were (1) to describe the state-of-the-science means of estimating economic values for ecosystem services, especially as relates to bioenergy; (2) to understand the potential benefits to farmers, rural communities, and the public of incorporating ecosystem service values in decision making; (3) to propose means of utilizing such knowledge for informed decision making by policymakers and regulators; and (4) to equip attendees with the knowledge and connections to return to their farms, universities, farms, legislatures, businesses, organizations, and agencies with actionable items to advance a vision of an improved Midwest agricultural system. This conference addressed USDA/NIFA program area priorities of a coordinated plan for a regional approach for feedstock development, production, and delivery to ensure sustainable production of biomass. This conference specifically emphasized net positive social, environmental, and rural economic impact.

Sponsors

USDA United States Department of Agriculture · National Institute of Food and Agriculture
Mississippi River Gulf of Mexico Watershed Nutrient Task Force
CARD Center for Agricultural and Rural Development
cenusa bioenergy
Iowa State University Bioeconomy Institute
IOWA EPSCoR Building Sustainable Energy Systems
University of Minnesota

Participants

Agricultural Watershed Institute
Argonne National Laboratory
Bill McGuire Conservation, LLC
Coastal Protection and Restoration Authority
DAK Renewable Energy
Environmental and Energy Study Institute
Environmental Working Group
Great Plains Institute
Green Lands Blue Waters
IDALS
Illinois EPA
Illinois Farm Bureau
Indiana Department of Agriculture
Institute for Agriculture and Trade Policy
Iowa Department of Agriculture and Land Stewardship
Iowa Department of Natural Resources
Iowa Farm Bureau Federation
Iowa State University
Iowa State University Bio Economy Institute
Iowa State University CenUSA Bioenergy
Kentucky Department for Environmental Protection
Leopold Center for Sustainable Agriculture
Louisiana Coastal Protection and Restoration Authority
Louisiana Department of Environmental Quality
Louisiana State University
Lower Mississippi River Sub-basin Committee
Minnesota Board of Water and Soil Resources
Minnesota Department of Natural Resources
Minnesota Pollution Control Agency
Mississippi State University
Missouri Department of Natural Resources
National Park Service
National Wildlife Federation
Natural Resources Defense Council
NOAA
Office of US Sen. Klobuchar
Prairie Lands Biomass LLC
Praxik, LLC
Purdue University
Rural Advantage
State of Kentucky
Tennessee Department of Agriculture
The McKnight Foundation
The Ohio State University
Union of Concerned Scientists
University of Illinois
University of Iowa
University of Kentucky
University of Minnesota
University of Minnesota-Extension
University of Missouri
University of Wisconsin
University of Wisconsin Extension
US Department of the Interior
US Environmental Protection Agency
US Fish & Wildlife Service
US Geological Survey
USDA
USDA/ARS
USDA/NIFA
USDA/NRCS
USEPA
USEPA R6
Wisconsin Rural Energy Management Council

Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops
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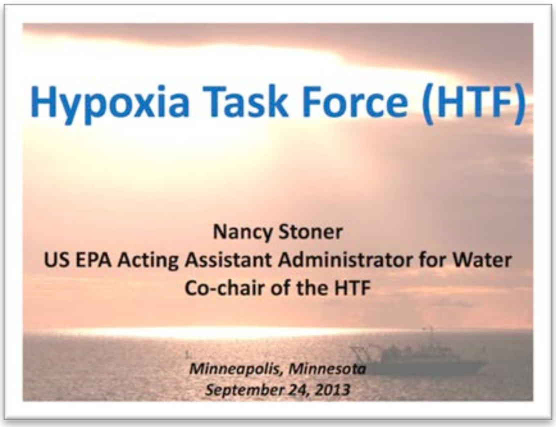
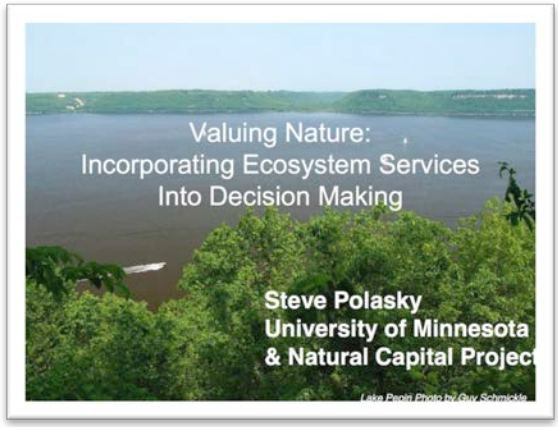
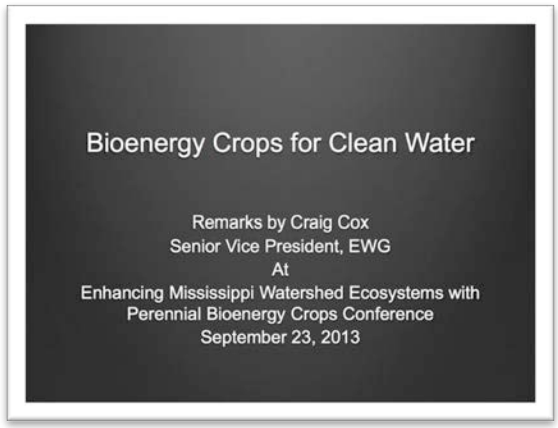
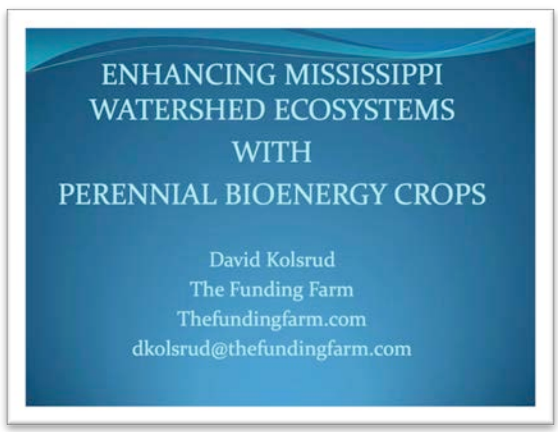
Presentations









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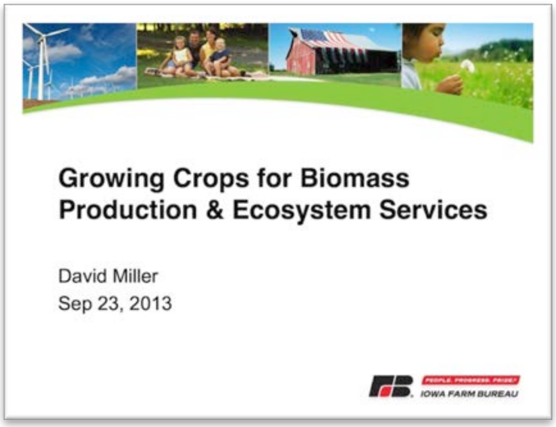

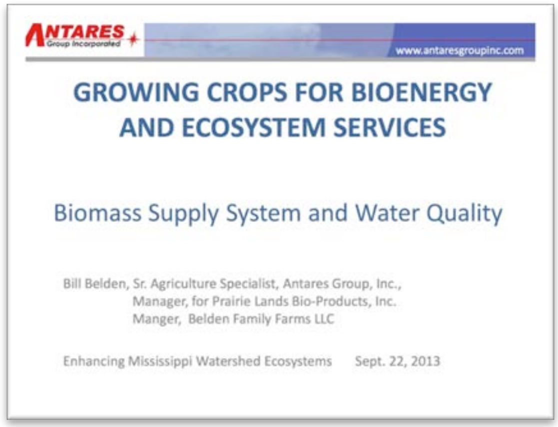

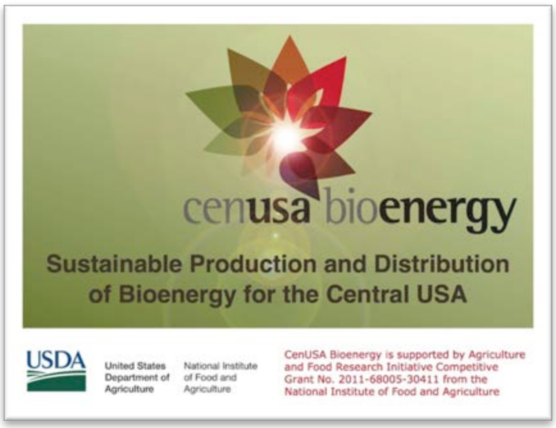

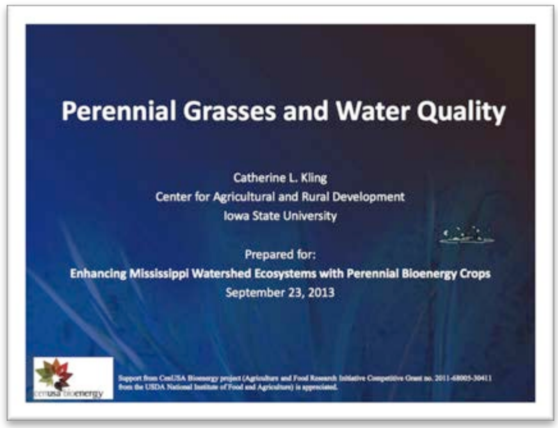

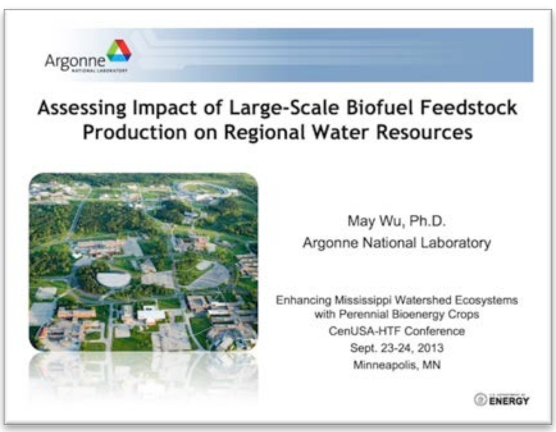

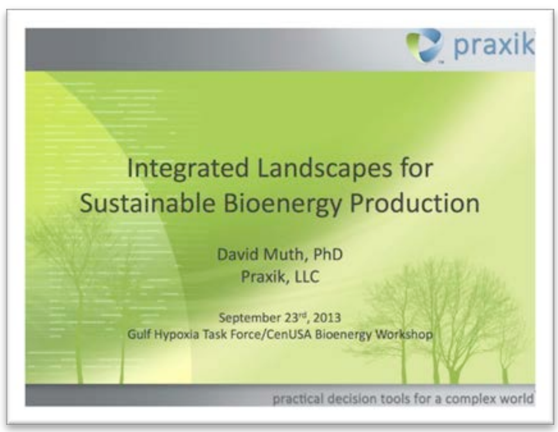

Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops

September 23–24 | Depot-Renaissance, Minneapolis, Minnesota

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- Dave Kleis, Mayor, St. Cloud, Minnesota

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*** Hosted by Hypoxia Task Force*

Exhibit 7

2013 Bioenergy/Hypoxia Task Force Survey

September 23-24, 2013, Minneapolis

27 Total Surveys

Please check the level that best fits you for each topic listed below.

BEFORE THIS MEETING:

	NONE		LOW		MODERATE		HIGH		Total Response		My Knowledge of…
1	1	4%	10	38%	10	38%	5	19%	26	96%	Growing perennial grasses to lower nutrient runoff
2	5	19%	8	30%	11	41%	3	11%	27	100%	Opportunities to develop a market for perennial grasses grown for biofuel production
3	3	11%	11	41%	9	33%	4	15%	27	100%	Economic drivers for growing perennial grasses for biofuel production
4	2	8%	11	42%	11	42%	2	8%	26	96%	The value of including incentives to grow perennial grasses in state nutrient reduction plans

AFTER THIS MEETING:

	NONE		LOW		MODERATE		HIGH		Total Response		My Knowledge of…
1	0	0%	1	4%	17	68%	7	28%	25	93%	Growing perennial grasses to lower nutrient runoff
2	1	4%	5	19%	16	62%	4	15%	26	96%	Opportunities to develop a market for perennial grasses grown for biofuel production
3	0	0%	3	12%	14	54%	9	35%	26	96%	Economic drivers for growing perennial grasses for biofuel production
4	0	0%	5	20%	17	68%	3	12%	25	93%	The value of including incentives to grow perennial grasses in state nutrient reduction plans

5. What is the most valuable information you learned at the meeting?

- Perspectives of farmers
- How perennial grasses could lower nutrient runoff
- Perennial grasses and their benefits
- It was good to hear both sides of the story
- All of it ☺
- Unless there is some baseline BMP requirements we won't make progress
- Farmers need to put on their big boy pants ☺

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.

- Increased my understanding about the work going on/related to hypoxia and how CenUSA and hypoxia have some common objectives
- Land already in CRP may not be a good target for perennial grasses production
- Gained perspectives
- Barriers for farmers to retain conservation lands and convert them to biofuels
- Other projects/initiatives going on
- $60 per ton cost in biomass production is just harvesting expense
- Use of grass to lower nutrient runoff
- A little more about invest praxik – Craig Cox perspectives!
- Policy and incentives associated with feedstock
- Spatial distribution is key to grow perennial grasses
- Switchgrass production cost
- Policy issues surrounding biofuel production
- David Math – crop insurance incentives
- How complex the solutions will be

6. How many people do you estimate you will share this information with?

0 to 5		6 to 10		11 to 20		21 to 50		51 to 100		more than 100		Total	
8	32%	1	4%	10	40%	1	4%	1	4%	4	16%	25	93%

7. What actions would you suggest for collaboration between the Hypoxia Task Force and CenUSA?

- Continue communications, especially if there are collaborate grants available to help with state strategies
- Keep the communications going – calls, meetings
- Define a common desired outcome and landscape target
- Most significant nexus niche is in implementation of targeted research and economic strategies
- Develop policy that supports the multiple benefits
- This meeting seems like a reasonable start
- Hold the workshop/meeting more often
- Targeting land that can reduce nutrient applications or serve as key buffer areas
- Continued combo meetings

8. **Your occupation: (please check all that apply)**
Other:

Farmer		Landowner		Educator		Government		Agribusiness		Other		Total	
4	14%	1	4%	3	11%	11	39%	1	4%	8	29%	28	104%

- NGO (3 responses)
- State Farm Bureau
- Researcher (2 responses)
- Admin non-profit

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EXHIBIT 8

CenUSA Advisory Board Comments
Project Progress: August 2012 - July 2013

Objective 1. Feedstock Development. Lots of progress made since last meeting. Good to see new varieties are living up to expectations and that publications are coming out. It would be good to see a report on biomass yields on a variety of agricultural lands and climates in the Corn Belt versus corn and other biomass crop alternatives. I would like to see stretch goals for yields in 5 and 10 years.

Objective 2. Sustainable Feedstock Production Systems. Good to see generation of information on inputs needed to maintain productivity and the effects on the biomass quality. It would be good to compare the costs of changing the biomass quality traits by breeding and agronomic tricks versus dealing with that trait in the pyrolysis step.

Objective 3. Feedstock Logistics. Good progress made in this area especially in looking at a variety of options for collection and storage. Still a huge tension between harvesting when it is most convenient versus when it allows for maximum return of nutrients to the roots. I think this needs to be addressed between all the groups. Maximum biomass yield and reliability of getting the biomass harvested versus the costs for nutrients and added processing costs need to be balanced. Also what processing steps should be done in the field versus the processing plant?

Objective 4. System Performance. Really need to come up with an overarching story about sustainability rather than just focusing on water quality or carbon sequestration even though these are the major political issues. Farmers will be much more concerned about minimizing inputs, maximizing year-to-year yields and making a profit in the end. I do think a good story needs to be made on economic benefit and a value proposition for overall sustainable production on the land.

Advisory Board

Tom Binder, Chair
Archer, Daniels, Midland

Albert Bennett
ICM, Inc.

Denny Harding
Iowa Farm Bureau Federation

Jerry Kaiser
USDA NRCS (MO, IA, IL)

Bryan Mellage
Agricultural Producer

Scott Rempe
Vermeer

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Nevada Economic Development Commission

David Stock
Stock Seed Farms

Jeremy Unruh
John Deere

Jay Van Roekel
Vermeer

John Weis
Agricultural Producer

Eric Zach
Nebraska Game & Parks Commission

CenUSA Bioenergy, a USDA-funded research initiative, is investigating the creation of a sustainable Midwestern biofuels system.

Research Partners

Iowa State University—Lead

USDA Agricultural Research Service (ARS)

Purdue University

University of Illinois

University of Minnesota

University of Nebraska–Lincoln

University of Vermont

University of Wisconsin

www.cenusa.iastate.edu

Objective 5. Feedstock Conversion/Refining. I was happy with the overview of the current biofuel production processes. I really think this group needs to model what the state of the art pyrolysis plant will produce, put an actual value on those products and provide this feedback along with groups 1, 2 and 3 to objective six so an overall economic model can be provided. Biochar needs to set a value for its sale and back this up with data on its benefits. Also needs to provide a report on what constitutes good biochar versus bad

Objective 6. Markets and Distribution. Very good report. This group needs real state of the art information from groups 1 thru five and stretch goals for 5 and ten years out so it can provide current economics and future economics. This will be very important information for government, researchers and the public. Along with this if Robert Brown could provide an engineering package for a pyrolysis plant it might make it possible for small cooperatives to engage in starting a business.

Objective 7. Health and Safety. Good progress toward looking at the safety of biomass production.

Objective 8. Education. Very good progress in under grad and grad programs. I think getting more open discussion about problems the various grad students and post-docs are facing, the more likely innovative solutions will be found. This group of people are still the most open to sharing ideas. Could the various investigators provide internships to high school science teachers to work along side their grad students? We have tried this this year and the teachers really had an eye opening summer.

Objective 9. Outreach and Extension. I liked the programs being developed. This group really needs to think about how to inform and remain objective in providing this information. Biomass advocates have had a long history of promotion without production of results. Information on options for biomass production and options for using that biomass needs to be developed and sent out. I would like all the trials with biochar by the various groups to report back about what worked and what did not work. Finding out what information the various stakeholders need and then providing this unbiased information back is critical.

Other Advisory Board Comments

- Education, education, education. Provide this to the media and politicians.
- Provide concise information on what can be done now.
- Harvesting issues need to be addressed, how high, how clean, best mode of operation.
- Information on where to get seed, what is the best marginal land to plant on, what are the risks and what are the alternate markets that the biomass might be used for.

- Provide a current pathway for the biomass and set values for the product so that economics can be determined. Provide this information to first movers in the Ag community.
- Inform the Ag community on new varieties and their potential as well as risks; provide webinars on best practices and markets.
- Take advantage now of wildlife habitat research opportunities.
- Get more representation from other industries interested in biomass conversion.
- Have a consistent set of yields and values in all the reports.
- How will the key issues of pyrolysis oils be resolved?
- Issues around current landlord/renter and 10 year cycle of perennial crop.

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

Exhibit 9

- Public sites
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  - Ask an Expert
  - Blogs
  - Campus
  - eXtension.org
  - Learn
  - Search
- Internal sites
  - Collaborate
  - Create
  - Data
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Extension Master Gardener

People. Plants. Partnerships
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- Gardens, Lawns, and Landscapes

« Almost Wordless Wednesday: Glorious Daylilies
Almost Wordless Wednesday: Follow up to National Moth Week »

CenUSA Annual Meeting Helps Extension Master Gardeners Connect Native Grass, Biochar and Biofuel Research

CenUSA Bioenergy annual meeting brings researchers and educators together to discuss multi-state biofuel research project.

We've been blogging about the CenUSA Bioenergy project and how Extension Master Gardeners are involved with biochar research at several research demonstration gardens in Iowa and Minnesota.

Extension Master Gardeners are involved in a small part of a large bioenergy project funded by a grant from the USDA National Institute of Food and Agriculture (AFRI). While attending my first annual meeting, I got the opportunity to see first-hand the whole scope of the grant."

Arriving at the CenUSA Bioenergy annual meeting held at Purdue's Beck Agricultural Center, we met 75 scientists, graduate students, and extension education professionals who were gathered to share and discuss the last year's progress related to developing and using native perennial grasses grown in the Midwest to create biofuels through the CenUSA Bioenergy project.

From grasses to biofuel to biochar

Extension Master Gardeners are involved with Objective 9 – Extension and Outreach, one of nine focus areas of the CenUSA Bioenergy project. Our extension counterparts at Purdue created excellent signage showing what this research project is seeking to accomplish (click images to read more closely).

Why use grasses for bioenergy?

Where will grasses be grown?

3 native perennial grasses

As you can see the goal is to develop high yield native perennial grasses to make biofuels. There are many potential benefits researchers see to producing biofuels from these grasses. For a great diagram of how these grasses are being studied to make biofuels, see: CenUSA Bioenergy's vision or this YouTube video.

Benefits of growing grasses for biofuels

Since the grasses are also native to our (Midwest) region, many see potential for using these as an energy crop on 'marginal land', or places where traditional crops like corn and soybeans do not perform well.

Another reason to use native perennial grasses for biofuels is that they may be environmentally friendly companions to traditional agricultural crops because of their ability to filter water and nutrient runoff, and possibly even providing habitat cover for animals.

This native grass is being predominately focused on throughout this research project is switchgrass. Other native grasses being studied include indiangrass, and big bluestem. Miscanthus giganteus, a tall, non-native, grass is also being researched and compared to the native perennial grasses.

Over the years I've been a bit captivated by ornamental grasses, so thinking about using these perennials grasses not just for landscaping, but for use as biofuel source that might someday fuel my car was quite intriguing.

Switchgrass grown as an ornamental grass in the landscape (Location: MN Landscape Arboretum)

Switchgrass grown and bred to be used as a biofuel crop (Location: Research plots, Purdue University)

What's needed to become a biofuel source?

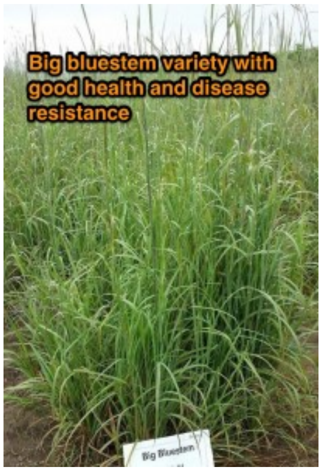
During the annual meeting (see more tour photos), we visited research plots where we saw different selections of all these grasses being grown and other 'energy crops' that researchers were comparing them to, such as poplar, sorghum, and corn. I found out the poplar trees (tallest plant shown in the photo below) are likely to be a better candidates for biofuels in northern regions of the country where growing seasons are cooler, shorter, and not suitable for growing native warm season perennial grasses.

Many different bioenergy crops gathered in Purdue University research plots

Researchers are looking to breed grasses that are broadly adaptable in a number of situations so they can tolerate a variety of environmental extremes, diseases, insect pests, and of course, the right makings to produce biofuel. Wimpy plants need not apply!

The following photos are a good comparison and reason why we need plant breeders involved in making new varieties and selections. Would you want to grow a disease prone grass (left photo) when you were depending on it to produce biofuels and part of your income? I would not!

Big bluestem with poor disease resistance



Big bluestem with good disease resistance

During the meeting, researchers discussed options for Optimizing Harvest of Perennial Grasses for Biofuel. Shortly after, there was much talk about how to convert grasses (sometimes called feedstock) to fuel, as well as economics and markets. It was quite interesting, but we'll skip to our favorite part of the meeting, the discussion about Objective 9 – Extension and Outreach! This is where the Extension Master Gardener and the biochar research fits in….

How our biochar research connects to the bigger pictures of producing biofuels?

The 2013 CenUSA Annual Meeting was an great opportunity to see the big picture of how all the pieces of a large biofuel research project can come together. If perennial grasses become a source of biofuel, it is possible the process that converts the perennial grasses to fuel (called pyrolysis) will create a by-product called biochar.

Extension Master Gardener team observe perennial grasses which some day may be a source of biofuel and biochar

Research has shown that biochar may hold promise as a soil amendment, offering potential benefits, such as improved water and nutrient capabilities, soil structure, and plant yield, while also reducing atmospheric carbon dioxide.

Conducting research to answer: Should we use biochars in our gardens?

As mentioned before, Extension Master Gardeners in Iowa and Minnesota are involved with research to ask the question: *Is biochar a good soil amendment for gardens?*

Planting day at the MN Landscape Arboretum biochar research demonstration garden.

As urban horticulturist and professor, Dr. Linda Chalker Scott mentions in her article, Should we use biochars in our gardens?:

> …there is little, if any, research on the use of biochars in non-agricultural situations other than soil remediation. This means no information on how it affects trees, shrubs, home gardens and landscapes, and other urban greenspaces. As readers of this blog should know by now, there are many agricultural production practices that do not translate well to the home garden or landscape.

As some of you may know, there is a lot of information floating around about biochar on the internet with some people claiming they have had great results on their vegetables by using biochar. Can biochar be over applied? Absolutely. Are all biochar created equal? No. That is why we believe there needs to be a lot more research about using biochar as a soil amendment along with safe labeling to determine the best application for the sites that benefit from it the most.

Gradually, our research is helping us develop some clues about biochar's properties in our seven research demonstration gardens that may someday help researchers be able to make sound recommendations for its use. We've shared many of these observations in past CenUSA Bioenergy blog posts, and will continue to share what we are learning from this research project in future posts.

In the meantime, some of us will be thinking about new ways some of our favorite ornamental and prairie grasses may be used as biofuel and biochar in the future, and perhaps you may be too…

-Karen Jeannette
Research Associate, University of Minnesota
CenUSA Bioenergy project

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

Tags: 2013 CenUSA Bioenergy Biochar Demonstration Garden Research, biochar, CenUSA Bioenergy

This entry was posted on Tuesday, August 27th, 2013 at 9:50 am and is filed under Projects, research, Soils. You can follow any responses to this entry through the RSS 2.0 feed. You can skip to the end and leave a response. Pinging is currently not allowed.

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Iowa Increases Public's Knowledge about Biomass

Cindy Haynes, Assoc Professor/Extension Hort
Yvonne McCormick, Extension Horticulturist
Iowa State University

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Exhibit 10

November 2013

CenUSA outreach and extension educators are making the public aware of the value of biochar through demonstration plots. Participants who attended four home demonstration field days in Iowa were surveyed to see how much their knowledge about biochar increased as a result of the educational programs that were presented.

Approximately 350 people attended one of the four 2013 Iowa Home Demonstration Garden Field Days showcasing the biochar test plots. Field days were hosted at Muscatine, Armstrong, and the Horticulture Station (2 field days) from mid-July to early August. There were 115 biochar surveys completed (33% response rate).

Before attending the field days,

- at least 77% of respondents had **low or no understanding** of biochar as a byproduct, its difference from charcoal, or the benefits and the economic value of biochar as a soil amendment;
- at least 76% had **low to no likeliness** of finding out more about biochar, using it, or telling others about biochar.

After the field day presentations,

- at least 80% had a **moderate to high understanding of biochar as a byproduct**, its difference from charcoal and its benefits as a soil amendment
- 72% of respondents had a **moderate to high understanding of the economic value**;
- at least 68% had a **moderate to high likeliness** of finding out more about biochar, using it, or telling others about biochar.

Sixty-eight percent of participants were over age 60, 65% were female, and 58% drove 11-50 miles to attend one of the field days.

Through demonstrations such as these, CenUSA Outreach and Extension is able to reach the public and increase their awareness and knowledge about biochar and its potential benefits in the home garden.

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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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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