cenusa bioenergy

Quarterly Progress Report

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

May 2017

Agriculture and Food Research Initiative Competitive Grant

No. 2011-68005-30411

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LEGAL NOTICE

Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (AFRI-CAP 2010-05073)

3rd Quarter Report: February 1, 2017 – April 30, 2017

Project Administration, Project Organization and Governance

Ken Moore (Professor, Iowa State University) continues as the CenUSA Bioenergy Project Director with Anne Kinzel as the Chief Operating Officer. Mary Scott Hall (ISU Bioeconomy Institute) provides assistance with project financial matters.

- **CenUSA Bioenergy Advisory Board**

  Our Advisory Board continues to be engaged in the project thorough Tom Binder's participation in leadership meetings.

- **Executive Team Meetings**

  The Co-Project directors representing each of the ten project objectives continue to meet monthly with Ken Moore and Anne Kinzel via online bimonthly meetings held in CenUSA's dedicated Adobe Connect meeting room. The virtual meeting room allows documents to be viewed by all participants, enhancing communications and dialogue among participants. Tom Binder, the Advisory Board chair also attends these meetings on behalf of the Advisory Board.

- **Financial Matters**

  The Administrative Team continues to monitor all project budgets and subcontracts to ensure adherence to all sponsor budgeting rules and requirements. We will be submitting a request for a No Cost Extension (NCE) at the beginning of the 4th Quarter. The NCE funds will be used for expenses associated with closing the CenUSA project, including development and deployment plans to ensure CenUSA's work product remains accessible to communities of interest, as well as the public. In addition, this will allow us time to complete the final annual report.

  Specifically, NCE funds will be used for administrative support in reporting, accounting and archiving project work product (ISU library services). The major expense will be salary support for administrative employees. This will allow us to meet all reporting requirements and let us make sure CenUSA Bioenergy products remain available to anyone who wants access to them.

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 2014, the focus was on the establishment of new breeding and evaluation trials.

1. Activities

The establishment and data collection from uniform field trials across the entire CenUSA region was completed at the end of Year 5. The initial analysis of biomass yield data from 65 trial-years was completed during the last quarter. Some of the findings are listed below.

- The trials confirmed the high yield of 'Liberty' switchgrass. It ranked fifth across all 65 trial-years, being beaten only by four new candidate varieties that represent highly selected lowland ecotypes, all developed after 'Liberty' was released. 'Liberty' was the highest ranked named variety for biomass yield across all 65 trial-years.

- Recent breeding efforts to develop new late-flowering switchgrasses and big bluestem for the northern USA has been extremely successful. For switchgrass, the top four rankings for biomass yield were made up of candidate lowland varieties selected in Nebraska, Illinois, or Wisconsin (three different breeding programs). For big bluestem, the top three ranks for biomass yield were contributed by the Nebraska and Wisconsin USDA breeding programs, ranking higher than all released varieties.

- These results show the incredible value of regional uniform field testing programs that are routine in annual crops, but have never been conducted on such a scale for switchgrass and big bluestem. These trials will allow intelligent decisions to be made about which selection criteria are the most successful, which environments are the best for selection, and which candidate varieties should be released to the public for seed increase.

- The results also show the regions of adaptation for these varieties, showing that there is still a need for improvement of winterhardiness in the improved lowland populations of switchgrass for USDA hardiness zones 3 and 4. Conversely, big bluestem showed no such problem, with broad adaptation across the entire region, even for the late-flowering varieties with the highest biomass yield.

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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.

- **Purdue University**

Perennial grasses such as, Miscanthus (*Miscanthus* × *giganteus*) and switchgrass (*Panicum virgatum*), are considered superior for the bioenergy production than annual grasses such as, maize (*Zea mays*) and sorghum (*Sorghum bicolor*) because of their ability to produce high biomass with relatively low nitrogen (N), phosphorus (P), and potassium (K) fertilizer inputs.

However, the relative contribution of these perennial and annual crops to total greenhouse gas (GHG) emissions, particularly on P- and K-deficient soils is not known. We compared GHG emissions from replicated side-by-side trials of an annual grass study (continuous maize and continuous sorghum) and three perennial grass studies (Miscanthus, switchgrass, and mixed native prairie) in 2013 and 2014. Except mixed native prairie, all crops had N treatments that included unfertilized and fertilized treatment (100 kg N ha^{-1} yr^{-1} for Miscanthus and switchgrass and 150 kg N ha^{-1} yr^{-1} for maize and sorghum). Miscanthus and switchgrass had additional P–K treatments, switchgrass was grown on plots that historically either received P–K treatment (75 kg P/ha with 400 kg K/ha per year) or were unfertilized and Miscanthus was either fertilized with a rate of 30 kg P/ha with 300 kg K/ha or were unfertilized. We conducted a weekly assessment of N_2O, CO_2, and CH_4 in situ fluxes from April to October in 2013 and 2014.

Miscanthus was most productive followed by sorghum, switchgrass, maize and mixed native prairie with 2-yr mean biomass yield of 24.9, 12.3, 10.8, 9.5, and 6.5 Mg ha^{-1}. The PK fertilization application had no impact on biomass yield of Miscanthus and switchgrass despite low soil test levels of P and medium soil test levels of K in control plots. However, the PK application interacting effect with N treatment in both crops to increase N_2O fluxes when measured after N fertilization in 2014. There were no treatment differences among daily CO_2 and CH_4 fluxes emissions in any study. Cumulative seasonal N_2O emissions were comparable among crops except for NPK treated Miscanthus plots in 2014, however, global warming potential measured as a sum of N_2O, CO_2 and CH_4 cumulative emissions per unit of biomass produced had very low values in Miscanthus. Clearly, these results indicate that Miscanthus can produce large amount of biomass with low direct total GHG emissions per unit of biomass produced when grown on low P, medium K and moderate erosivity lands and thus could serve as a potential dedicated energy crop to meet nation's targets of produce biofuels from cellulosic feedstocks.

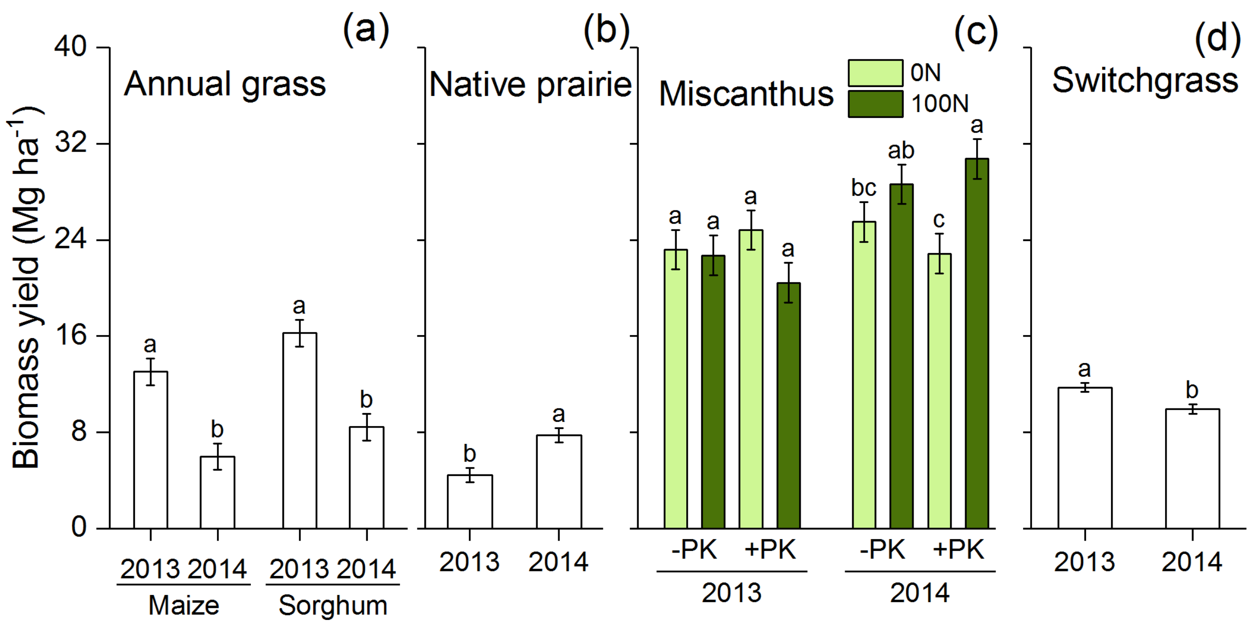

Fig. 1. Mean aboveground dry biomass yield in 2013 and 2014 of (a) annual grass (maize and sorghum), (b) native prairie, (c) Miscanthus and (d) switchgrass biomass systems. Standard errors are provided. Different lowercase letters over the vertical bars indicate there is significant difference ($P < 0.10$) between 2013 and 2014 mean dry biomass yield within a biomass system, except the Miscanthus experiment where different lowercase letters over the vertical bars identify significant differences ($P < 0.10$) between PK and N fertilizer treatments within years.

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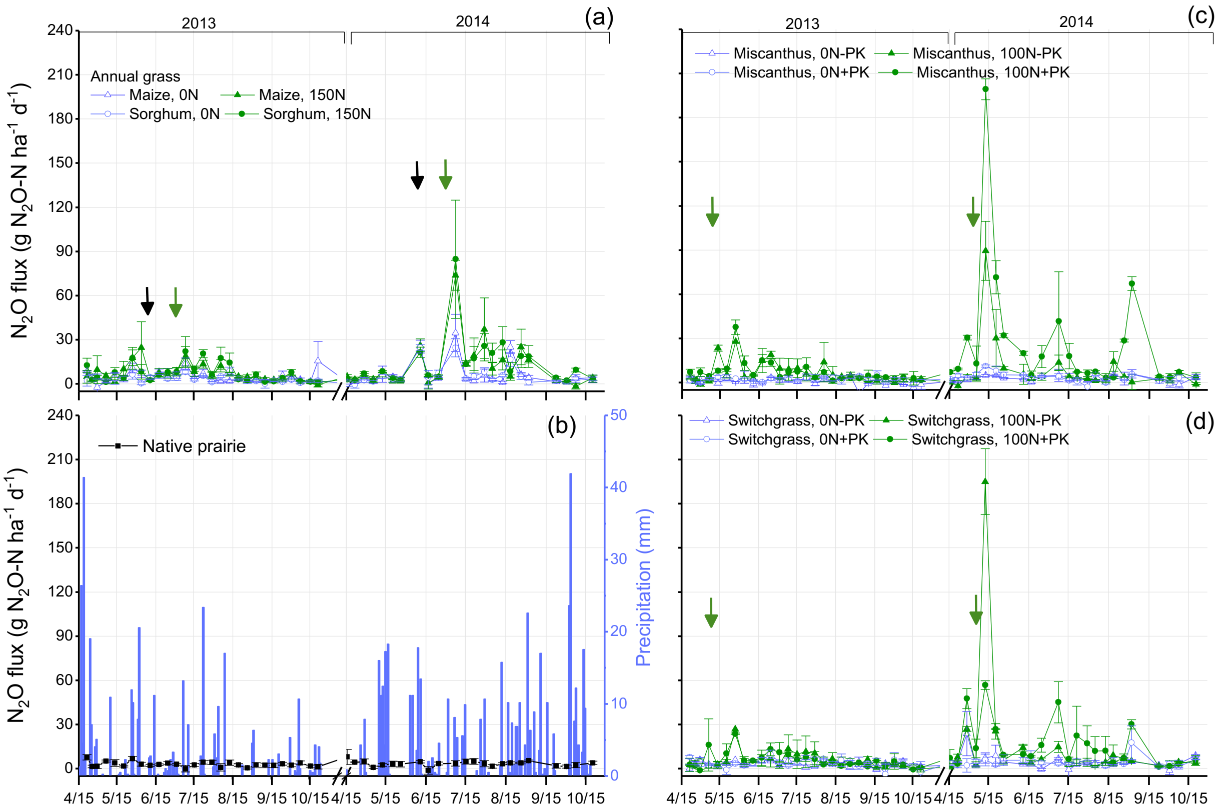

Fig. 2. Mean daily N_2O flux measured between April 22 and October 22 in 2013 and between April 16 and October 21 in 2014 by treatment in (a) annual grass, (b) native prairie, (c) Miscanthus, and (d) switchgrass study. Error bars represent standard errors of mean dry biomass yield based on replicated plots (n= 4, 4, 2, and 2 in annual grass, native prairie, Miscanthus, and switchgrass study, respectively). Downward-pointing black arrows indicate date of planting and downward-pointing green arrows indicate date of fertilizer application. Vertical bars in (b) represent daily total precipitation received from April 15 to October 30 in 2013 and 2014 at the Throckmorton Purdue Agricultural Center, Lafayette, IN.

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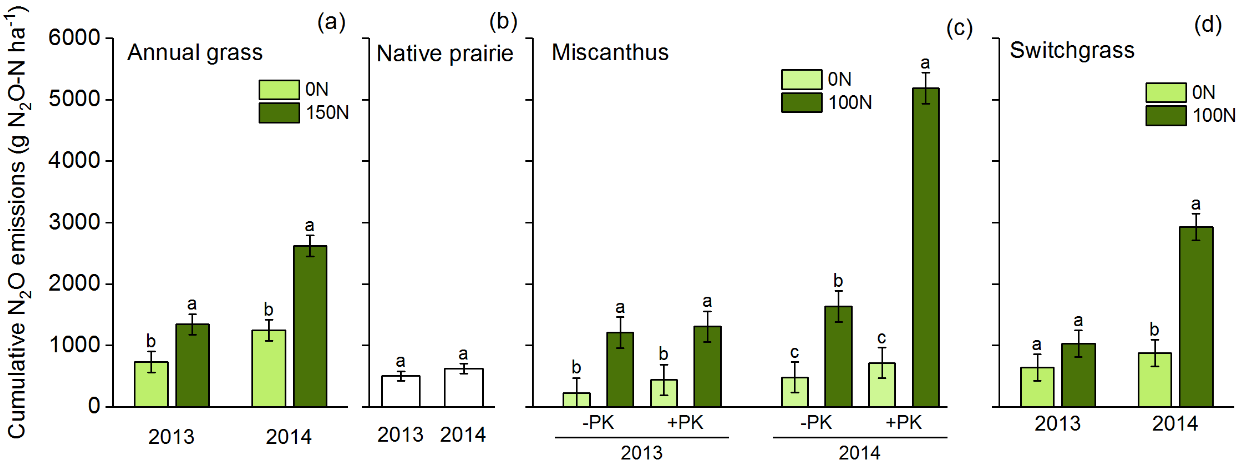

Fig. 3. Mean cumulative N_2O-N emissions calculated between April 22 and October 22 in 2013 and between April 16 and October 21 in 2014 as influenced by (a) N rate × year interaction in the annual grass study, (b) N rate × year interaction in the switchgrass study, (c) PK rate × N rate × year interaction in the Miscanthus study, and (d) by year in the native prairie study. Error bars represent standard errors of mean cumulative N_2O-N emissions based on replicated plots (n= 4, 4, 2, and 2 in annual grass, native prairie, Miscanthus, and switchgrass study, respectively). Different lowercase letters over the vertical bars indicate there is significant difference ($P < 0.10$) in mean cumulative N_2O-N emissions among two N treatments in 2013 and 2014 in annual grass and switchgrass study while in Miscanthus different lowercase letters over the vertical bars indicate there is significant difference ($P < 0.10$) between PK and N fertilizer treatments within years.

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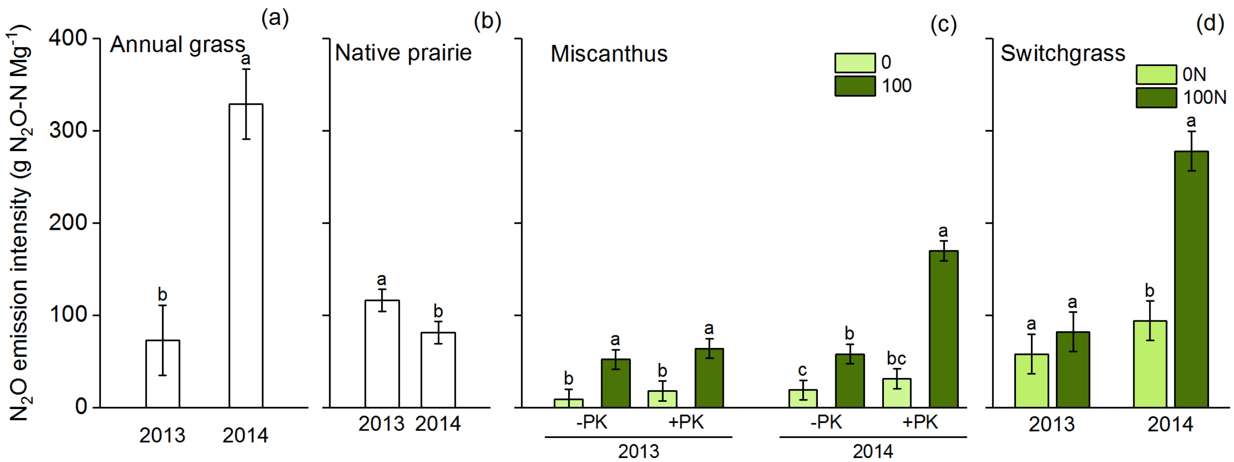

Fig. 4. Mean N_2O-N emission intensities calculated as the ratio between cumulative N_2O-N emissions (kg N_2O–N ha^{-1}) between April 22 and October 22 in 2013 and between April 16 and October 21 in 2014 and their respective aboveground biomass yield (Mg ha^{-1}) as influenced by (a) year in the annual grass, (b) year in the native prairie, (c) PK rate × N rate × year interaction in the Miscanthus, and (d) N rate × year interaction in the switchgrass study. Error bars represent standard errors of mean N_2O-N emission intensities on replicated plots (n= 4, 4, 2, and 2 in annual grass, native prairie, Miscanthus, and switchgrass study, respectively). Different lowercase letters over the vertical bars indicate there is significant difference ($P < 0.10$) in mean N_2O-N emission intensities of two years in annual grass and native prairie study and different lowercase letters over the vertical bars in the switchgrass indicate there is significant difference ($P < 0.10$) among two N treatments in 2013 and 2014 while in Miscanthus different lowercase letters over the vertical bars indicate there is significant difference ($P < 0.10$) between PK and N fertilizer treatments within years.

- **University of Illinois**

  We are currently conducting analyses of four years of data and writing manuscripts for publication in refereed journals.

- **University of Minnesota**

  - **Becker Location**

    We completed our post-frost harvest on October 13, 2016. Samples have been weighed, dried, and ground.

  - **Lamberton Location.**

    We completed our post-frost harvest on October 26, 2016. Samples have been weighed, dried, and ground.

  - **Additional Activities.**

    Anne Sawyer is making progress on her dissertation using data collected from CenUSA.

The first chapter, “Switchgrass and mixed perennial biomass production as affected by nitrogen fertility and harvest management,” examines near-anthesis and post-frost yield data and N uptake/removal from three switchgrass cultivars (‘Liberty,’ ‘Shawnee’ and ‘Sunburst’) and three perennial polycultures at Becker (2012-2015) and Lamberton (2013-2016). We are working on internal revisions prior to submission for publication.

Chapter 2, “Rhizobacterial community structure as a function of cultivar and nitrogen in switchgrass grown on two marginal soils”, explores the community of rhizosphere bacteria in unfertilized and fertilized (112 kg N ha-1) ‘Liberty’, ‘Shawnee’ and ‘Sunburst’ from the near-anthesis harvest in 2014 using high-throughput sequencing of the 16S rRNA gene. We will submit this chapter for publication after review by Anne’s dissertation committee.

Chapter 3 “Cultivar and phosphorus fertilization effects on switchgrass biomass yield, phosphorus removal, and rhizosphere microflora.” It is similar to Chapter 2 in using high-throughput sequencing of the 16S rRNA gene in bacteria, but also includes sequencing of the ITS region in fungi. Post-frost switchgrass biomass yield and P removal in ‘Liberty,’ “Shawnee”, and ‘Sunburst’ was evaluated at four P rates (0, 22, 45 and 67 kg P2O5 ha-1) over three years, and near-anthesis rhizosphere microflora community structure was evaluated in all cultivars at 0 and 67 kg P2O5 ha-1. As with Chapter 2, we will submit this chapter for publication after review by Anne’s dissertation committee.

Anne Sawyer’s defense is scheduled for June 15, 2017, and she anticipates graduating in July 2017.

- **USDA-ARS, Lincoln**
  - **Actual Accomplishments**
    - ✓ Completed all field work.
    - ✓ Predicted samples from multiple locations.
    - ✓ Completing equipment repair, fence repair, and field updates following field trials.
    - ✓ Ground, milled, and scanning all Nebraska samples.
  - **Current Actions**
    - ✓ **Demonstration Plots**

      Yield data for 2012-2016 is being summarized.
    - ✓ **Factor Analysis Plots**

- ➢ Yield data for 2012-2016 is being summarized.
- ➢ Samples collected in 2012, 2013, 2014, 2015, & 2016 have been processed and are being scanned and predicted.

✓ **System Analysis Plots**

- ➢ All samples are being scanned and predicted.
- ➢ Mineral analysis samples have been completed and NIRS prediction is being developed.
- ➢ GHG samples from 2013-2015 are being summarized.
- ➢ VOM and elongated leaf height data are being summarized.
- ➢ Harvest height and harvest date data are being summarized.
- ➢ Bales were weighed and transported.
- ➢ Seed production areas were burned.
- ➢ Triticale was sampled.
- ➢ Corn was planted.

- **Plans for Next Quarter**
  - ✓ Scan and predict biomass samples forwarded from other locations.
  - ✓ Finalize mineral data and work on NIRS prediction equation.
  - ✓ Finalize the scanning and predicting of 2012, 2013, 2014, 2015, and 2016 Nebraska biomass samples.
  - ✓ Analyze and summarize field data.
  - ✓ Submit manuscripts on CenUSA projects.

- **Table 1.** Field scale yields for 'Liberty' switchgrass, big bluestem, a low diversity mixture, corn grain, and corn stover from rainfed fields near Mead, NE from 2012 through 2016. Yields represent 3 field replicates and are the mean of two fertilizer treatments (50 & 100 lb N/acre) since there was no clear response to N application. Perennial grasses were established in 2012, and grass yields from 2013-2016 represent the total dry matter that was harvested, baled, and transported from the field to the storage facility. Perennial grass means include the planting year. Herbicide damage from glyphosate in 2014 reduced switchgrass yields in 2014 and 2015.

Table 1. Field scale yields for 'Liberty' switchgrass, big bluestem, a low diversity mixture, corn grain, and corn stover from rainfed fields near Mead, NE from 2012 through 2016.

Feedstock	2012	2013	2014	2015	2016	2017
Liberty switchgrass	3.4	5.1	4.5	4.6	5.7	4.7
Big bluestem (t/a)	1.2	4.1	4.7	4.3	5.4	3.9
LD Mixture (t/a)	1.9	5.0	5.7	5.7	6.1	4.9
Corn (bu/acre)	103.0	149.0	139.0	126.0	145.0	132.0
Stover (t/a)	1.4	1.9	1.8	1.7	1.6	1.7

- **Table 2.** Field scale yields for 'Liberty' switchgrass, big bluestem, and a low diversity mixture from rainfed demonstration fields near Humboldt, Nebraska and Beaver Crossing, Nebraska in 2016. Yields represent 2 field replicates and are the mean of three fertilizer treatments (0, 60 & 120 lb N/acre). Perennial grasses were established in 2012 at Humboldt and 2013 at Beaver Crossing and data represents the total dry matter that was harvested, baled, and weighed in the field in 2016.

Table 2. Field scale yields for 'Liberty' switchgrass, big bluestem, and a low diversity mixture from rainfed demonstration fields near Humboldt, NE and Beaver Crossing, NE in 2016.

Feedstock	Humboldt, NE	Beaver Crossing, NE	Mean
Liberty switchgrass (t/a)	3.4	5.1	4.5
Shawnee switchgrass (t/a)	1.2	4.1	4.7
LD Mixture (t/a)	1.9	5.0	5.7

- **USDA-ARS, Madison**

Currently summarizing data and writing papers. Two manuscripts are partially written. Tentative titles are:

- Nitrogen fertilization and harvest date effects on biomass yield and nutrient removal of switchgrass.
- Soil nitrogen responses to nitrogen fertilization and differential harvest dates of switchgrass.

2. Publications / Presentations/Proposals Submitted

- Participated in the DOE/USDA Bioeconomy Initiative: Action Plan Coordination Meeting, USDOE, Washington, DC, April 5-6, 2017.
- We are preparing to host Switchgrass IV, Prairie and Native Grass International Conference in Lincoln, NE, August 7-10, 2017.
- We leveraged CenUSA research sites to garner additional funding from the North-Central SunGrant on the project "Growing Bioenergy Crops on Marginally Productive Croplands: Implications on Erosion and Water Quality Parameters."
- We leveraged the Crop/Livestock/Bioenergy Production System Demonstration site in eastern Nebraska to get additional funding through the SDSU NIFA-CAP to increase sampling intensity and graze the site.
- Bonin C.L., R.B. Fidel, C. Banik, D.A. Laird, R.B. Mitchell & E. Heaton. 2017. Perennial biomass crop establishment, community characteristics, and productivity in the upper Midwest: Effects of cropping systems seed mixtures and biochar applications. Agriculture, Ecosystems and the Environment (submitted).
- Blanco-Canqui, H., R. Mitchell, V. Jin, M. Schmer & K. Eskridge. 2017. Perennial warm-season grasses for producing biofuel and enhancing soil properties: An alternative to corn residue removal. GCB Bioenergy. doi: 10.1111/gcbb.12436. Open access.
- Cibin, R., I. Chaubey, R.L. Muenich, K.A. Cherkauer, I. Panagopoulos, P.W. Gassman & C.L. Kling. 2017. Ecosystem service evaluation of futuristic bioenergy based land use change and their uncertainty from climate change and variability. J. American Water Resources Association. In Press.
- Gassman, P.W., A. Valcu, C.L. Kling, Y. Panagopoulos, R. Cibin, I. Chaubey, C.F. Volter & K.E. Schilling. 2017. Assessment of cropping scenarios for the Boone River watershed in North Central Iowa, United States. J. American Water Resources Association. In Review.
- Kling, C.L., I. Chaubey, R. Cibin, P.W. Gassman & Y. Panagopoulos. 2017. Policy implications from multi-scale watershed models of biofuel crop adoption across the Corn Belt. J. American Water Resources Association. In Press.
- Panagopoulos, Y., P.W. Gassman, C.L. Kling, R. Cibin & I. Chaubey. 2017. Assessment of large-scale bioenergy cropping scenarios for the Upper Mississippi and Ohio-Tennessee River basins. J. American Water Resources Association. Accepted.

Objective 3. Feedstock Logistics

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

Iowa State University

1. **Planned Activities**

   Research activities planned included:

   - Development and validation of biomass "drying prediction models" to predict relative increase in biomass moisture levels during a rainfall event and subsequent drying profile after the re-wetting of biomass materials.
   - Continued development and evaluation of prototype real-time biomass moisture sensor for switchgrass and corn stover.

2. **Actual Accomplishments**

   During this quarter, the emphasis has been on the completion of the analysis, writing and submission of journal articles.

   An improved biomass drying prediction models has been developed. This model uses a random forest (RF) classification based algorithm, to predict moisture content (MC) of switchgrass (SW) and corn stover (CS). RF was able to predict the moisture content of switchgrass (SW) and corn stover (CS) with a coefficient of determination of 0.77 and 0.79, respectively. Hours after harvest, average solar radiation intensity, change in radiation intensity, rainfall, VPD were found to be the most important factors affecting the MC of CS. Drying CS in low density (LD) and medium density (MD) swaths facilitated quick drying even in moderate drying conditions and density were found to be higher in importance than other variables used for model development. Rainfall events ranging from 1.5 to 7.5 mm were experienced during the switchgrass drying period which delayed the crop drying by one day to several days depending on the weather conditions after rainfall. Several rewetting events were also observed due to dew at night and early morning which increased the MC in LD switchgrass and CS by 5 to 15%. The models developed in current study will help in decision making of switchgrass and CS collection after harvest based on forecasted weather conditions in lower Midwestern states.

A book chapter to be published in CRC Biomass Preprocessing Book, has been submitted and reviewed and is expected to be published in July 2017. A journal article has been submitted to Agricultural and forest meteorology Journal for review.

3. **Explanation of Variance**

No variance in planned activities has been experienced.

4. **Plans for Next Quarter**

Research activities planned during next quarter include:

Completion of all data analysis, and submission of journal articles.

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

- Khanchi, A. & S.J. Birrell. 2017. Modeling the influence of crop density and weather conditions on field drying characteristics of switchgrass and corn stover using random forest. Agricultural and Forest Meteorology Journal (Submitted).
- Khanchi, A. B Sharma, A.K. Sharma, A Kumar, J.S. Tumuluru & S.J. Birrell. 2017. Effects of Biomass Preprocessing Technologies on Gasification Performance and Economic Value of Syngas. Book Chapter submitted to CRC Biomass Preprocessing Book Chapter. (Submitted, to be published July 2017).

University of Wisconsin

1. **Planned Activities**

Our efforts in this quarter were to include:

- Re-design the experimental high-density baler to address crop flow issues.
- Continue to compress large square biomass bales to increase the dataset size.
- Continue work on twine tension for large square bales.
- Continue the outdoor storage study of large square bales covered with breathable film.
- Complete manuscripts for publication review.

2. **Actual Accomplishments**

- We have acquired a new baler pick-up and we have completed the redesign of the experimental baler to accommodate this pick-up. We have started parts fabrication and modifications. Tests are planned for early summer.

- Compression data for large-square biomass bales of biomass has been delayed until a new crop becomes available this summer. We purchased components to allow lab test of twine knot failures. We have developed samples of various restraining materials using different ways to make twine knots. We have developed a protocol to measure twine knot failure and is in the process of test and improvement before actual replicated tests begin.
- We began a storage study in the fall where the main objective is to explore cost-effective means to store large-square-bales (LSB) outdoors. These bales are being monitored for moisture content and temperature during the storage period and will be removed from storage in mid-summer.
- Two publications previously submitted for peer review have been reviewed. One has been published and the other is undergoing minor revisions. Work has shifted to two new publication dealing with biomass harvest energy requirements and LSB twine tension.

3. Explanation of Variance

Work has progressed as planned.

4. Plans for Next Quarter

Our efforts in the next quarter will include

- Finish fabrication and modifications to the experimental high-density baler.
- Continue to compress large square biomass bales to increase the dataset size.
- Continue work on twine tension for large square bales.
- Continue the outdoor storage study of large square bales covered with breathable film.
- Complete two additional manuscripts for publication review.

5. Publications, Presentations, and Proposals Submitted

- Shinners, K.J. and J.C. Friede. 2017. Enhancing switchgrass drying rate. BioEnergy Research, doi:10.1007/s12155-017-9828-5.
- Shinners. K.J., B.K. Sabrowsky; C.L. Studer & R.L. Nicholson. 2017. Switchgrass harvest progression in the North-Central US. Submitted to BioEnergy Res. (2 Feb.) Now accepted pending minor revisions.

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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**

   Our efforts remain focused on moving the set of four manuscripts submitted to the Journal of the American Water Resources Association SWAT Special Series through the review process. Abstracts are again provided for the four manuscripts as Exhibit 1 to this report.

2. **Actual Accomplishments**

   As reported previously, two of the manuscripts (Kling et al. and Cibin et al.) are now accepted (see citations below). The Panagopoulos et al. manuscript is now tentatively accepted and final acceptance of that study is expected soon. Meanwhile, the Gassman et al. manuscript has gone through a second review that resulted in more requested revisions, after the manuscript was sent to an entirely new reviewer who did not participate in the original review. Revisions are being performed to that manuscript with a goal of resubmitting it by the end of May 2017.

3. **Explanation of Variance**

   No variance has been experienced.

4. **Plans for Next Quarter**

The main goal is to complete the review and obtain final acceptance from JAWRA of the Gassman et al. manuscript.

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

- Cibin, R, I. Chaubey, R.L. Muenich, K.A. Cherkauer, P. Gassman, C. Kling and Y. Panagopoulos. 2016. Ecosystem Services Evaluation of Futuristic Bioenergy-based Land Use Change and Their Uncertainty from Climate Change and Variability. J. Am. Water Resour. Assoc.(accepted).
- Gassman, P.W., A. Valcu, C.L. Kling, Y. Panagopoulos, C. Raj, I. Chaubey, C.F. Wolter, K.E. Schilling. 2016. Assessment of Bioenergy Cropping Scenarios for the Boone River Watershed in North Central Iowa, United States. J. Am. Water Resour. Assoc. (in review).
- Kling, C.L., I. Chaubey, C. Raj, P.W. Gassman, Y. Panagopoulos. 2016. Policy Implications from Multi-Scale Watershed Models of Biofuel Crop Adoption across the Corn Belt. J. Am. Water Resour. Assoc. (accepted).
- Panagopoulos, Y., P.W. Gassman, C.L. Kling, R. Cibin and I. Chaubey. 2016. Assessment of Large-scale Bioenergy Cropping Scenarios for the Upper Mississippi and Ohio-Tennessee River Basins. J. Am. Water Resour. Assoc. (first review received; revisions being performed).

University of Minnesota

1. **Planned Activities**

We continued submission of manuscripts from output of previous quarters.

2. **Actual Accomplishments**

This quarter, we resubmitted, after revision, two manuscripts related to the output of previous quarters: the first on the air quality impacts of increased switchgrass production, and the second on the output of the modeling platform developed to support air quality impact assessment. One paper, by Tessum et al. and supported in part by CenUSA, was published (See below).

3. **Explanation of Variance**

No variance has been experienced.

4. **Plans for Next Quarter**

Continued submission of manuscripts from output of previous quarters.

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

Tessum C.W., Hill J.D. & J.D. Marshall. 2017. InMAP: A model for air pollution interventions. PLoS ONE 12(4): e0176131. https://doi.org/10.1371/journal.pone.0176131 Open Access.

Post-Harvest

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

This portion of the project is complete.

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 to produce 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**

Continue work on the economic feasibility of grasses, modelling the optimization problem of a unique plant under different market structures and, using assumptions based on local commercial biomass processors, estimate input requirements and costs of grass feedstocks to meet the cellulosic mandate.

2. **Actual Accomplishments**

Graduate student Ryan Goodrich, who was previously supported by the CenUSA project, successfully completed his preliminary oral exam to become a PhD candidate in the Department of Economics at Iowa State University. Ryan's dissertation work is on the supply of biomass for bioenergy using spatially explicit models that account for crop location, distances to processing, and operational cost factors.

3. **Explanation of Variance**

None. All activities are moving forward according to the project schedule.

4. **Plans for Next Quarter**

- We will develop a survey that will be used to identify the producer and land characteristics that may be used to infer optimal collection strategies for grasses from that used for stover, and

- We will finalize the work on the economic feasibility of grasses, including a summary of our findings from the CenUSA project and suggestions for future work to advance knowledge of markets and efficient distribution systems.

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

- Co-PD Jacobs presented worked funded by CenUSA at C-FARE's Conference in Washington, D.C. February 17, 2017. "American-made BioEnergy from Field to Refinery: Feedstock Logistics." The CenUSA project was the catalyst for the research on which the presentation was based.

- Co-PDs Hayes and Jacobs along with recent PhD Chao Li submitted a paper for peer-review at the American Journal of Agricultural Economics, "Competition, delivery mechanisms and market outcomes for cellulosic feedstock."

Objective 7. Health and 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 Biofeedstocks**

   - **Planned Activities**

The reviewers’ comments will be address for the *Journal of Agricultural Safety and Health* manuscript. Page proofs are expected to be review and this journal article be completed. The authors will also address comments raised by the eXtension.org reviewer.

- **Actual Accomplishments**

The reviewers’ comments were addressed for the *Journal of Agricultural Safety and Health* manuscript. The editor indicated adjustment to reviewers’ comments was accepted and the manuscript was ready for publication. The final step will be reviewing page proofs before printing.

Page proofs for the *Journal of Agricultural Safety and Health* by the American Society of Agricultural and Biological Engineers have not arrived as expected. The delay in receiving page proofs are expected to be connected with American Society of Agricultural and Biological Engineers staff preparing for annual conference.

The authors addressed comments raised by the eXtension.org reviewer about the research summary posted on eXentsion.org website. Additionally, corrections were submitted that were generated by the review of the manuscript by *Journal of Agricultural Safety and Health*.

- **Explanation of Variance**

See above.

- **Plans for Next Quarter**

Page proofs are expected to be review and this journal article be completed.

- **Publications, Presentations, and Proposal Submitted**

  - ✓ Ryan, S. J., C. V. Schwab & G. A. Mosher. 2017. Agricultural worker injury comparative risk assessment methodology: assessing corn and biofuel switchgrass production systems. J. Ag Safety & Health. (In Press).

  - ✓ Ryan, S. J., C. V. Schwab & H. M. Hanna. 2017. Research summary: overview of comparative injury risk between annual corn and perennial switchgrass production. eXtension.org website http://articles.extension.org/pages/74211/research-summary:-overview-of-comparative-injury-risk-between-annual-corn-and-perennial-switchgrass-

2. **Task 2 – Assessing Primary Dust Exposure**

- **Planned Activities**

Have one or two pilot samples taken.

- **Actual Accomplishments**

  No samples have been taken at this time.

- **Explanation of Variance**

  None to report.

- **Plans for Next Quarter**

  Have one or two pilot samples taken and the analysis of the pilot dust exposure completed.

- **Publications, Presentations, and Proposal Submitted**

  No publication, presentations or proposal submitted from this task.

Education and Outreach

Objective 8. Education

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

- 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 a 10-week summer internship program modeled on the highly successful NSF REU (research experience for undergraduates) program. Subtask 2B is **training graduate students** via a two-week summer intensive program modeled on a highly successful industry sponsored intensive program in biorenewables the team led in 2009. Subtask 2C is **training graduate students** via a monthly research webinar. The next portion of this report is broken into subtasks.

Subtask 1: Curriculum Development

1. Planned Activities

- Continue editing final module content.
- Determine repository location for modules at end of CenUSA project term.

- **Module 10 – Plant Breeding**

  Convert draft content to an on-line version.

- **Module 16 – Quality and Nutrient Management**

  Continue editing module content.

2. **Actual Accomplishments**

We decided to keep Ohio State University (OSU) ATI as repository location for CenUSA module program content due to uncertainty associated with future support for maintaining and additional development work for the module program. All modules will be stored in Canvas format for use at OSU and in PDF format where appropriate.

- **Module 10 – Plant Breeding**

  We converted the draft content to an on-line version.

- **Module 16 – Quality and Nutrient Management**

  We suspended work on this module in lieu of work on Module 10.

- **Module 17 – Plant Pathology for Warm-Season Grasses**

  We prepared the online lesson and are waiting the review from the technical expert.

3. **Explanation of Variance**

We suspended work on this module in lieu of work on Module 10.

4. **Plans for Next Quarter**

- **Module 10. Plant Breeding**

  We will review the draft on-line lesson and make edits as needed.

- **Module 17 – Plant Pathology for Warm-Season Grasses**

  We will review the draft online lessons and make edits as needed.

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

   None to report this period.

Subtask 2A: Training Undergraduates via Internship Program

1. **Planned Activities**

   None as this was strictly a prior year activity. No forward planning is required.

2. **Actual Accomplishments**

   None as this was strictly a prior year activity. No forward planning is required.

3. **Explanation of Variance**

   None.

4. **Plans for Next Quarter**

   None as this was strictly a prior year activity. No forward planning is required.

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

   None to report in this period.

Subtask 2B – Training Graduate Students via Intensive Program

1. **Actual Accomplishments**:

   None as this was strictly a PY2 and a PY4 program activity. No forward planning is required.

2. **Explanation of Variance**
   None.

3. **Plans for Next Quarter**:

   None as this was strictly a PY2 and a PY4 program activity. No forward planning is required.

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

   None.

Subtask 2C –Subtask 2C – Training Graduate Students via Monthly Research Webinar

1. **Planned Activities**

   This series will no longer be offered; however graduate students will be invited to participate in critical project meetings as objectives disseminate findings in this final year.

2. **Actual Accomplishments**

   None as this was strictly a PY1 - PY4 program activity. No forward planning is required.

3. **Explanation of Variance**

   None.

4. **Plans for Next Quarter**

   None as this was strictly a PY1 - PY4 program activity. No forward planning is required.

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

   None.

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 public awareness of perennial crops and biochar agriculture.
  - Certified Crop Advisor training.

- **Economics and Decision Tools Team**

  The Economics and Decision Tools Team focuses 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. **Current Activities**

     Nearly all the activities of the CenUSA Extension Team wrapped up in December 2016. Below, please find descriptions of the three activities that continued into 2017:

     - Video clips for the final CenUSA video, which will feature information about pyrolysis, have been gathered and the storyboard for the video has been completed. The video will be completed and archived to the CenUSA web sites by the end of June 2017 and will be shared via social media and the CenUSA website.

     - The Iowa State University CenUSA Extension Economics team continued to promote the CenUSA Switchgrass Decision Tool at meetings with farmers and conservationists during February and March 2017. 119 people downloaded/completed the CenUSA Decision Tool (http://www.extension.iastate.edu/AgDM/crops/html/a1-29.html) this quarter. This brings total downloads and completions during the CenUSA project to 809, exceeding our project goal by 309!

     - The bulk of work in this quarter has centered on preparing for two teacher training events for the CenUSA C6 BioFarm program that will be conducted in June 2017. The first will be held in collaboration with Morningside College in Sioux City, IA on June 6, 14, 15 and 16. The course syllabus has been completed (Exhibit 2), and the class has been approved for both teacher renewal credit and graduate credit, on-line systems for teacher "homework" and course evaluation have been drafted and tours have been arranged. The class is fully subscribed.

- The second teacher training event will be held in conjunction with the National Ag in the Classroom Conference (June 20-23, see: https://naitcconference.usu.edu/). CenUSA is a sponsor for the conference. Jill Euken and Jay Staker will be providing CenUSA C6 BioFarm plenary and breakout sessions and staffing a CenUSA C6 exhibit during the conference.

2. Plans for Next Quarter

- Complete and post CenUSA pyrolysis video.
- Execute the CenUSA C6 BioFarm teacher trainings.
- Complete final quarterly report and final project for CenUSA Extension.

3. Google Analytics Data

- **CenUSA Website.** The CenUSA web site had 519 unique visitors this quarter. These visitors logged a total of 1,472 pageviews during 667 sessions. Pageviews are the total number of pages that visitors looked at during their time on the site. A session qualifies as the entire time a user is actively engaging with the site. If activity ceases for an extended period, and the user returns, a new session is started.

- **Continuing Impact of Vimeo Channel**. During this quarter, the 54 CenUSA videos archived on Vimeo have had 211 plays or views of the videos on our Vimeo site, or on a web site that embedded a CenUSA video. The 54 videos also had 4,814 loads; 927 of those loads came from our videos embedded on other sites. This is a significant increase over last quarter's 125 views and 1,107 loads and reflects our continued efforts to publicize our video resources using social media. When a video is loaded, people see the video but they do not click "play". Vimeo videos were downloaded 8 times (0 last quarter). This means the video was saved to their hard drive (users usually do this because they have limited Internet connectivity which does not allow for live streaming of a video). Once the video is downloaded, it is available on their computer to watch at their convenience.

- **Continuing Impact of YouTube Channel**. CenUSA videos are also posted on

YouTube, and those videos have been viewed 1577 times between February 1, 2017 and April 30, 2017 (1385 views last quarter). 967 views were from the United States. Demographic analytics report an audience that is 84% male and 16% female. Our viewers ranged in age from 13-65+. The top 3 represented age groups were 18-24 (23%), 25-34 (23%), and 35-44 (21%).

YouTube also provides data related to how users access the videos. Videos were viewed on their associated watch page, the YouTube Channel page, or on web pages where the videos were embedded. 97% of the videos were viewed on their associated YouTube watch page (each video has a unique "watch page"). Embedded videos on another site accounted for 2.8% of the views. Our top 4 traffic sources for this quarter include: YouTube search, YouTube suggested videos, referrals from other web sites, and browse features (subscription feed, homepage navigation options, etc.). 43% of our views came from users accessing videos suggested by YouTube.

YouTube search accounted for 30% of our views. Referrals from outside YouTube (google search or access through external web sites) account for 15% of the video views. Browse features accounted for 12% of video views.

- **Twitter**. Twitter traffic consists of followers who subscribe to our account and "follow" our tweets (announcements). Followers can "favorite" a tweet, or retweet it to share with their own followers. CenUSA bioenergy has 1049 followers currently, up from 977 followers last quarter
- **Facebook**. By the end of January 2017, CenUSA's Facebook page had 264 likes, up from 254 the previous quarter.

Objective 10. Commercialization - Renmatix

During Q3 we conducted a number of experiments related to lignin's ability to perform as an anti-oxidant in thermoplastics. The results from those experiments are just now coming in and being reviewed. Results will be reported during the next quarter.

Exhibit 1

Exhibit 1. Abstracts for set of four studies submitted to the Journal of the American Water Resources Association (JAWRA)

- Kling, C.L., I. Chaubey, C. Raj, P.W. Gassman & Y. Panagopoulos. 2016. Policy Implications from Multi-Scale Watershed Models of Biofuel Crop Adoption across the Corn Belt. *Journal of the American Water Resources Association* (accepted).

  Abstract: The implications and value of SWAT-based simulations of the productive potential and water quality impacts associated with switchgrass, Miscanthus or corn stover removal biofuel cropping systems are discussed. Specifically, the three accompanying studies describe the water quality implications of adopting the three biofuel cropping systems via large-scale conversion of cropland or targeting to marginal lands for three smaller watersheds located in the western or eastern Corn Belt, or across the Upper Mississippi and Ohio-Tennessee River Basins. Other results such as climate change related impacts for two eastern Corn Belt watersheds are also discussed. These studies are supported by the CenUSA Bioenergy coordinated agricultural project funded by the USDA to develop a regional system for producing cellulosic biofuels. A description of the evolving federal policy related to cellulosic biofuel production and consumption is provided as are other potential drivers for encouraging the adoption of stover removal, switchgrass, and Miscanthus as perennial feedstocks. Findings from the SWAT studies and their implications for environmental and economic performance in their respective agroecosystems are discussed, and commonalities and divergences in results are identified. The potential for policy design to improve the performance of these systems based on the findings of these modeling studies, and continuing research needs and directions for improved policy design are discussed.

- Cibin, R, I. Chaubey, R.L. Muenich, K.A. Cherkauer, P. Gassman, C. Kling & Y. Panagopoulos. 2016. Ecosystem Services Evaluation of Futuristic Bioenergy-based Land Use Change and Their Uncertainty from Climate Change and Variability. *Journal of the American Water Resources Association* (accepted).

  Abstract: Land use change can significantly affect the provision of ecosystem services and the effects could be exacerbated by projected climate change. We quantify ecosystem services of bioenergy based land use change and estimate the potential changes of ecosystem services due to climate change projections. We considered seventeen bioenergy based scenarios with Miscanthus, switchgrass, and corn stover as candidate bioenergy feedstock. Soil and Water Assessment Tool simulations of biomass/grain yield, hydrology and water quality were used to quantify ecosystem services fresh water provision (FWPI), food (FPI) and fuel provision, erosion regulation (ERI), and flood regulation (FRI). Nine climate projections from Coupled Model Intercomparison Project phase-3 were used to quantify the potential climate change variability. Overall, ecosystem services of heavily row cropped

Wildcat creek watershed were lower than St. Joseph River watershed which had more forested and perennial pasture lands. The provision of ecosystem services for both study watersheds were improved with bioenergy production scenarios. Miscanthus in marginal lands of Wildcat creek (9% of total area) increased FWPI by 27% and ERI by 14% and decreased FPI by 12% from the baseline. For St. Joseph watershed, Miscanthus in marginal lands (18% of total area) improved FWPI by 87% and ERI by 23% while decreasing FPI by 46%. The relative impacts of land use change were considerably larger than climate change impacts in this study.

- Gassman, P.W., A. Valcu, C.L. Kling, Y. Panagopoulos, C. Raj, I. Chaubey, C.F. Wolter & K.E. Schilling. 2016. Assessment of Bioenergy Cropping Scenarios for the Boone River Watershed in North Central Iowa, United States. *Journal of the American Water Resources Association* (revised and resubmitted).

  Abstract: Several biofuel cropping scenarios were evaluated with an improved version of SWAT as part of the CenUSA Bioenergy consortium for the Boone River watershed (BRW), which drains about 2,370 km^2 in north central Iowa. The adoption of corn stover removal, switchgrass or Miscanthus biofuel cropping systems were simulated to assess the impact of cellulosic biofuel production on pollutant losses. The stover removal results indicate that removal of 20% or 50% of corn stover in the BRW would have negligible effects on streamflow and relatively minor or negligible effects on sediment and nutrient losses, even on higher sloped cropland. Complete cropland conversion to switchgrass or Miscanthus resulted in streamflow or sediment, nitrate and other pollutant reductions ranging between 23% to 99%. The predicted nitrate reductions due to Miscanthus adoption were over two times greater compared to switchgrass, with the largest impacts occurring for tile drained cropland. Targeting of switchgrass or Miscanthus on cropland ≥ 2% slope or ≥ 7% slope revealed that a disproportionate amount of sediment and sediment-bound nutrient reductions could be obtained by protecting these relatively small areas of higher sloped cropland. Overall, the results indicate that all biofuel cropping systems could be effectively implemented in the BRW, with the most robust approach being corn stover removal adopted on tile drained cropland in combination with a perennial biofuel crop on higher sloped landscapes.

- Panagopoulos, Y., P.W. Gassman, C.L. Kling, R. Cibin & I. Chaubey. 2016. Assessment of Large-scale Bioenergy Cropping Scenarios for the Upper Mississippi and Ohio-Tennessee River Basins. *Journal of the American Water Resources Association* (first review received; revisions being performed).

Abstract: The Upper Mississippi River Basin (UMRB) and Ohio-Tennessee River Basin (OTRB) comprise the majority of the U.S. Corn Belt Region. The combined basins are the primary U.S. food, feed and biofuel production region, resulting in degraded Mississippi River and Gulf of Mexico water quality. To address the water implications of increased biofuel production, biofuel scenarios were tested with a SWAT mode revision featuring improved biofuel crop representation. Scenarios included corn stover removal and switchgrass or Miscanthus grown on marginal lands (slopes>2% and erosion rates>2 t/ha), non-marginal lands, or both. The results reveal that stover removal is environmentally neutral, even in the most sloping and erodible marginal land and perennial bioenergy crops can reduce sediment, nitrogen (N) and phosphorus (P) yields by up to 60%. In particular, sediment and P reductions were generally twice in the marginal than in the non-marginal lands, but the highest unit area reductions of N occurred in the less sloping tile-drained lands. Productivity results showed that corn grain yield was independent from stover removal, while both switchgrass and Miscanthus yields were similar in the marginal and non-marginal lands. The study indicates that biofuel production planning in the Corn Belt may include the removal of stover in highly productive corn areas and the growth of perennials in the environmentally marginal land and in the lowland tile drained areas of the highest N pollution.

Exhibit 2

NORTHWEST AREA EDUCATION AGENCY

PROFESSIONAL DEVELOPMENT PROGRAM
PROPOSED COURSE SYLLABUS

Directions: This information is **required** for activities offered for credit through the Northwest AEA Professional Development Program. This is an electronically fillable form with spaces that expand as you complete them.

All syllabi need to be submitted and approved in advance of the beginning of the course.

General Course Information - Required for all activities

Instructors/Instructors of record: *For site-based activities indicate who will evaluate participant works.*	Dr. Thomas Paulsen, PhD Associate Professor and Chair Applied Agricultural and Food Studies Morningside College paulsent@morningside.edu Jill Euken, Deputy Director Bioeconomy Institute Iowa State University Ames, IA 50011 jeuken@iastate.edu
	C6 BioFarm Educational Game Suite and Curriculum
Course registration:	☒ Open (show course on web) ☐ Site based (available to select group only – "hidden" registration)
Course description: *This should be 3 to 5 sentences in length and should identify content, purpose, and/or focus of the class.*	C6 BioFarm is a game suite and curriculum designed to help middle and high school students learn about non-renewable (fossil-based) carbon, renewable carbon and agricultural production practices. Participants in this course will learn how to implement the C6 BioFarm game suite, which includes an iPad/Android tablet app, teacher curriculum, iBook, and career videos, in their classroom.
Target audience:	Middle and High School Agricultural Education and STEM teachers
Credit:	☒ Licensure renewal (required) ☒ Graduate credit (optional) *Requirements have changed for graduate credit. Please note the changes under participant evaluation.*
# of credit hours requested: *15 collaborative/contact hours per credit minimum. Don't count mealtime or independent work time.*	1 License renewal credit 1 Morningside credit

Cost Options - Select one

☒ **Option 1**	**No instructor fee will be paid**. **Reduced rate** requested - $35/credit hour for licensure renewal or $85/credit hour for graduate from Morningside College
☐ **Option 2**	**Instructor stipend (up to $650) paid from registrations.** (There must be a minimum of 10 registrants for this option. For fewer than 10 registrants, the stipend will be prorated.) $85/credit hour for licensure renewal or $135/credit hour for graduate from Morningside College or Briar Cliff University, $155/credit hour from Drake University or Viterbo University. (All Graduate credit is dependent on approval of syllabus by college).
☐ **Option 3**	**Other –** If other arrangements need to be made, please contact the Professional Development Office in advance for approval.

Specific Activity Information – Required for all activities

Location: *Be specific – course set-up requires exact location*	The course will be held on the campus of Morningside College in the Weikert Auditorium in Buhler Rohlfs Hall. Some sessions will be held in a wet lab in the Walker Science Center. Parking will be free and in the Grace Methodist Church lot on the Southeast side of campus.
Proposed meeting dates: *Be specific – course set-up requires exact dates* **Proposed meeting times:** *Be specific – course set-up requires specific times*	Date | June 6: | 10 am – 12:00 pm and 1:00 pm – 4:00 pm for all students via Adobe Connect; 5 hours June 14: | at Morningside College (Weikert Auditorium – Buhler Rohlfs Hall); begin at 9:00 am; adjourn at 5 pm 7 hours June 15: | at Morningside College (Weikert Auditorium – Buhler Rohlfs Hall); begin at 8 am; adjourn at 5 pm 8 hours June 16: | at Morningside College (Weikert Auditorium – Buhler Rohlfs Hall); 8 am – 3 pm 6 hours Additional group meeting work (evenings) to plan for team teaching sessions arranged by participants – 4 hours
Proposed ending date: *Be specific – exact date that all work will be due.*	On-campus course ends June 16. Coursework due June 30.
Minimum class size: *Not required for site-based activities*	6
Maximum class size: *Not required for site-based activities*	12
Proposed registration deadline *(for site-based activities only)*	March 15

Additional Information - open registration activities only

Course materials required for participants: *If a book or published materials are required, please provide name of book/material, author(s), publisher and date, ISBN, and contact information for supplier: Cost for the book will be included in the registration fee.*	Curriculum and resource materials are available on-line (http://www.extension.iastate.edu/4h/content/c6-biofarm)
Equipment needed by *instructor:* *Technology and other equipment, i.e. DVD, projector.*	LCD projector
Comments to be printed in confirmation letter regarding materials, mealtime, etc.	A printed copy of the curriculum will be provided to participants. There will be a 30-minute lunch break (food available on site) and one 15-minute break each morning and afternoon

***Course Development** – Required for all activities*

List the learning goals/objectives for this activity. *What should participants know or be able to do upon completion of this activity? These should be tied to the evaluation criteria below.*	Participants will demonstrate competence in using the plans and materials in the C6 BioFarm curriculum to help students learn about: - Fossil vs renewable carbon sources - Role of carbon in the energy cycle - Environmental impacts of biomass production for fuels, chemicals, power - Impacts of different agricultural practices on soil conservation and health, biomass collection, managing air and water pollution, bioenergy production and development - Biomass conversion technologies (pyrolysis, gasification, fermentation) - Production of biorenewable products in their community - How to reduce personal carbon footprint - Impacts of climate change on food, fuel and fiber sources - STEM careers related to biorenewable energy - Economic, social and environmental impacts of food, fuel, fiber production
Activity Syllabus/Content *How will the participants achieve the stated learning goals/objectives? It should include a detailed outline of the professional development and should include theory, demonstration and practice as appropriate.*	Specific STEM concepts related to C6 will be provided throughout the sessions with just-in-time teaching. Participants will master the lessons and demonstrate teaching the lessons to their colleagues in the class to familiarize themselves with the curriculum, allow for pedagogical development and learn necessary preparation for the lessons. The schedule overview (below) is designed to focus primarily on theory on Day 1 and on demonstration and practice on Day 2-4. Assignments will also provide documentation of learnings. 1. Day 1 (June 6): 5 hours of background theory via Adobe Connect or something similar; topics will include: overview of perennial grass production for biofuels and bioproducts; thermochemical conversion of biomass to fuels and chemicals; overview of class syllabus; overview of C6 BioFarm curriculum; assignments and details regarding teaching Lessons 1-6 of the curriculum 2. Day 2 (June 14th): convene at 9:00 am; Group 1 teaches Lesson 1; Group 2 teachers Lesson 2; Field trip to producers who are implementing perennials on the landscape for water quality or other reasons; adjourn at 5pm

	3. Day 3 (June 15th): Group 3 will do Lesson 3; Group 4 will do Lesson 4; Group 5 will do lesson 5; tour to ethanol plant; adjourn at 5 pm 4. Day 4 (June 16th): Group 5 will do Lesson 5; Group 6 will do Lesson 6; discussion of additional resources, evaluation tools and plans, group activity – groups do brainstorming about implementation; wrap-up; adjourn at 3:00 pm 5. "Homework" assignments for all participants
What research supports this activity? *Please cite sources and briefly summarize the information referenced.*	The C6 BioFarm curriculum and game suite are based on a six-year (2011-2016), $25M research project called **CenUSA Bioenergy** conducted by faculty and staff from Iowa State University, University of Nebraska, Purdue University, University of Wisconsin, University of Minnesota and the USDA ARS. Research was organized around themes of biomass production, biomass logistics, biomass conversion technologies, and environmental impacts of biomass production and utilization. Research summaries, fact sheets and videos were prepared for each of the topic areas listed above and are archived at: http://articles.extension.org/pages/72584/resources-from-cenusa-sustainable-production-and-distribution-of-bioenergy-for-the-central-usa. This site also includes a list of publications in professional journals that were produced from the CenUSA research.
How does this professional development assist teachers in planning to meet the needs of diverse learners in their classrooms?	By experiencing the lessons as teachers and learners, participants will be able to socially construct (based on the diversity complex in their own teaching situation) appropriate accommodations to meet the needs of diverse learners in their classrooms
Which of these Iowa Teaching Standards are primarily supported by this professional development?	☒ Standard 1: Demonstrates ability to **enhance academic performance** and support for implementation of school district's student achievement goals. ☒ Standard 2: Demonstrates competence in **content knowledge** appropriate to teaching position. ☒ Standard 3: Demonstrates competence in **planning and preparing for instruction**. ☒ Standard 4: Uses strategies to **deliver instruction that meets the multiple learning needs of students**. ☒ Standard 5: Uses a variety of methods to **monitor student learning**. ☐ Standard 6: Demonstrates competence in **classroom management**. ☒ Standard 7: Engages in **professional growth**. ☒ Standard 8: Fulfills **professional responsibilities** established by school district.
Which Equity Issue does this course/professional development address (mark all that apply)? *Describe how issues will be addressed during professional development.*	☐ Multi-cultural Issues ☐ Gender Fair Issues ☒ Socio-economic Issues ☐ English Language Learners ☐ Other Diverse Learners (e.g. TAG and students with special needs)

**** Additional Information** – Site-based registration activities only*

Summarize your data and prioritized student needs. Also indicate whether this professional development is designed to address district-wide needs or attendance center needs.	

Is this a face-to-face class or a study group for collaborative action research?	☒ Face-to-face *(most or all of the time will be spent in large group instruction)* ☒ Study group for collaborative action research *(some or all of the time will be spent collaboratively in small groups reviewing student data and reflecting on practice and logs will be kept).*
What implementation and/or student data will teachers collect and how frequently will it be collected?	Reflections will be collected following each lesson
When will planned collaboration and reflection occur?	Teachers will be teamed with a colleague to plan and teach one of the lessons of the curriculum. The two-person teams will schedule their collaboration/planning meeting at a mutually agreeable time between the kick-off meeting on June 6 and the in-person meeting on June 14. Reflections will be done after each lesson and collected from each participant at the end of each day of the training
Building administrator approving this activity	William Deeds, Provost – Morningside College Thomas Paulsen, Associate Professor – Morningside College Laura Staber, Central Scheduling Coordinator – Morningside College
AEA contact *(when appropriate)*	Carolyn Smith

Participant Evaluation –For licensure renewal only course

(Do not complete this section if course is for Graduate Credit)

What are the requirements for successful course completion and how will you assess that participants have met the stated learning goals/objectives stated above? **Renewal credit is Pass/Fail.* ***Specific criteria is required.*** *"Instructor judgment" is not adequate. A rubric may be helpful.* **FYI – Attendance should not be part of your grading scale. All participants must attend 100% of the time to earn any credit.*	N/A This course is offered for graduate credit.

Participant Evaluation – Required for graduate credit course

(Requirements are the same for License Renewal credit – Pass is equal to A or B grade)

Graduate Credit offered from Morningside College, Briar Cliff University, Drake University, and Viterbo University. Participants select the institution of their choice for credit.

What are the requirements for successful course	Each participant will be responsible for preparing and teaching one lesson from the curriculum and will participate in the learning activities	Approximate out-of-class time required

completion and how will you assess that participants have met the stated learning goals/objectives stated above? **One graduate credit requires a total of 45 hours. A minimum of 15 hours must be class time: contact/collaboration with instructor/facilitator.* **You must include letter grade delineation for A, B, C, D, and F. Specific criteria is required "Instructor judgment" is not adequate.* ***A rubric is required.*** **FYI – Attendance should not be part of your grading scale. All participants must attend 100% of the time to earn any credit.*	led by their colleagues which will allow for content knowledge evaluation. Participants will also be expected to complete and turn in reflection reports following each lesson experience describing how they will utilize the knowledge gained and the materials developed in their local school district to positively impact teaching and learning in their classroom. Participants will also be asked to identify the appropriate state Teaching Standard and Criteria for their Teaching Portfolio. See Attached grading rubric and grading scale. Out of Class Work: - Read/watch/research summaries/fact sheets/videos from the CenUSA Resource list: http://articles.extension.org/pages/72584/resources-from-cenusa-sustainable-production-and-distribution-of-bioenergy-for-the-central-usa in topic areas related to the lesion plans to be developed (see below) - Develop three complete lesson plans with assessments and an implementation plan for their local curriculum from the content presented in the course - Write and submit lesson reflections - Identify and crosswalk the activities to the National Standards for Agriculture, Math and Science	to complete each activity. 2 hours 6 hours 3 hours 4 hours

Instructor of record information

***New Requirement: All instructors need to submit an official Transcript and Resume to the Professional Development Coordinator.*

Complete Personal Information if instructor has not previously taught for the Professional Development Program or Update if Information has changed.

Name: Dr. Thomas H. Paulsen Jill Euken	Title: Associate Professor – Applied Agricultural and Food Studies Department, Morningside College Title: Deputy Director, ISU Bioeconomy Institute, Iowa State University, Ames, IA 50011
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Paulsen Home phone: (712) 830-2733 Euken Home phone: (712) 769-2284	Work phone: (712) 274-5489 Work phone: (515) 249-6286	Email:paulsent@morningside.edu Email: jeuken@iastate.edu
Paulsen BA/BS institution: NWMSU Euken BS, Iowa State University	Field of study/Year completed: Agricultural Education 1987 Field of Study: Family and Consumer Sciences Education (Permanent teaching certificate for grades 7-12) 1976	
Paulsen MA/MS/MAT institution: Iowa State University Euken MS, Iowa State University	Field of study/Year completed: Agricultural Education 2001/Principal Licensure 2005 Field of Study: Rural Sociology, 1979	
Paulsen EdS and/or EdD/PhD institution: Iowa State University	Field of study/Year completed: PhD 2011	

For approval, submit to:
Carolyn Smith
Instructional Coach/Professional Development Coordinator
Northwest Area Education Agency
1520 Morningside Ave. Sioux City, IA 51106
Phone: 712-222-6033 or WATS: 800-352-9040 x 6033
Email: casmith@nwaea.org

"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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