Enabling Sustainable Landscape Design for Continual Improvement of Operating Bioenergy Supply Systems

(Award No: EE0007088)

U.S. Department of Energy (DOE)
Bioenergy Technologies Office (BETO)
2019 Project Peer Review,
March 6, 2017
Denver, CO

Analysis & Sustainability Session

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Goal Statement

This project will develop and demonstrate new tools and approaches for planning and implementing *sustainable landscape design strategies aimed at simultaneously improving farm profitability, environmental sustainability, and future sustainable biomass supply production*, thereby improving the viability of future herbaceous biomass supply systems and projects.

Project Outcomes

- Case study examples for various demonstrated strategies
- Field monitoring results and data, multiple years
- Applied analytical tool improvements
- Landscape Design “Handbook”
- Increased state and local experience with these strategies

Quad Chart Overview

Timeline

- Project start date: April 1, 2016
- Project end date: March 31, 2021
- % complete: 50% Schedule (on-track)
  49% Funds

Source of Funds	FY 17 & FY18 Costs	Total Planned Funding (FY 19-End)
DOE Funded	**$4.42M**	**$9.00M**
Project Cost Share	**$1.45M**	**$1.50M**
IDALS	*$1.23M*	*$1.27M*
Others	*$0.22M*	*$0.23M*

Partners: IDALS (21%), USDA ARS (17%), Antares (15%), FDCE (13%), INL (10%), PSU (6%), AgSolver (5%), ORNL (4%), ANL (2%), All Others (7%)

Barriers addressed

- **At-B.** Analytical Tools and Capabilities for System-Level Analysis
- **At-C.** Data Availability across the Supply Chain
- **At-E.** Quantification of Economic, Environmental, and Other Benefits and Costs
- **At-F.** Science-Based Methods for Improving Sustainability
- **At-G.** Social Acceptance and Stakeholder Involvement

Objective

Advance the state-of-the-art for sustainable bioenergy landscape design processes.

End of Project Goal

Landscape Design “Handbook” with applied, demonstrated, documented, measured, and reported improvements and lessons learned.

1 - Project Overview

Required Areas of Focus:

1. Multi-Stakeholder Landscape Design Process
2. Assessment of Environmental Sustainability Indicators
3. Assessment of Feedstock Supply and Logistics
4. Help to build a template for future biorefinery projects

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OAK RIDGE National Laboratory

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Iowa Agricultural Bio Fibers

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FDC Enterprises Grasslands Services

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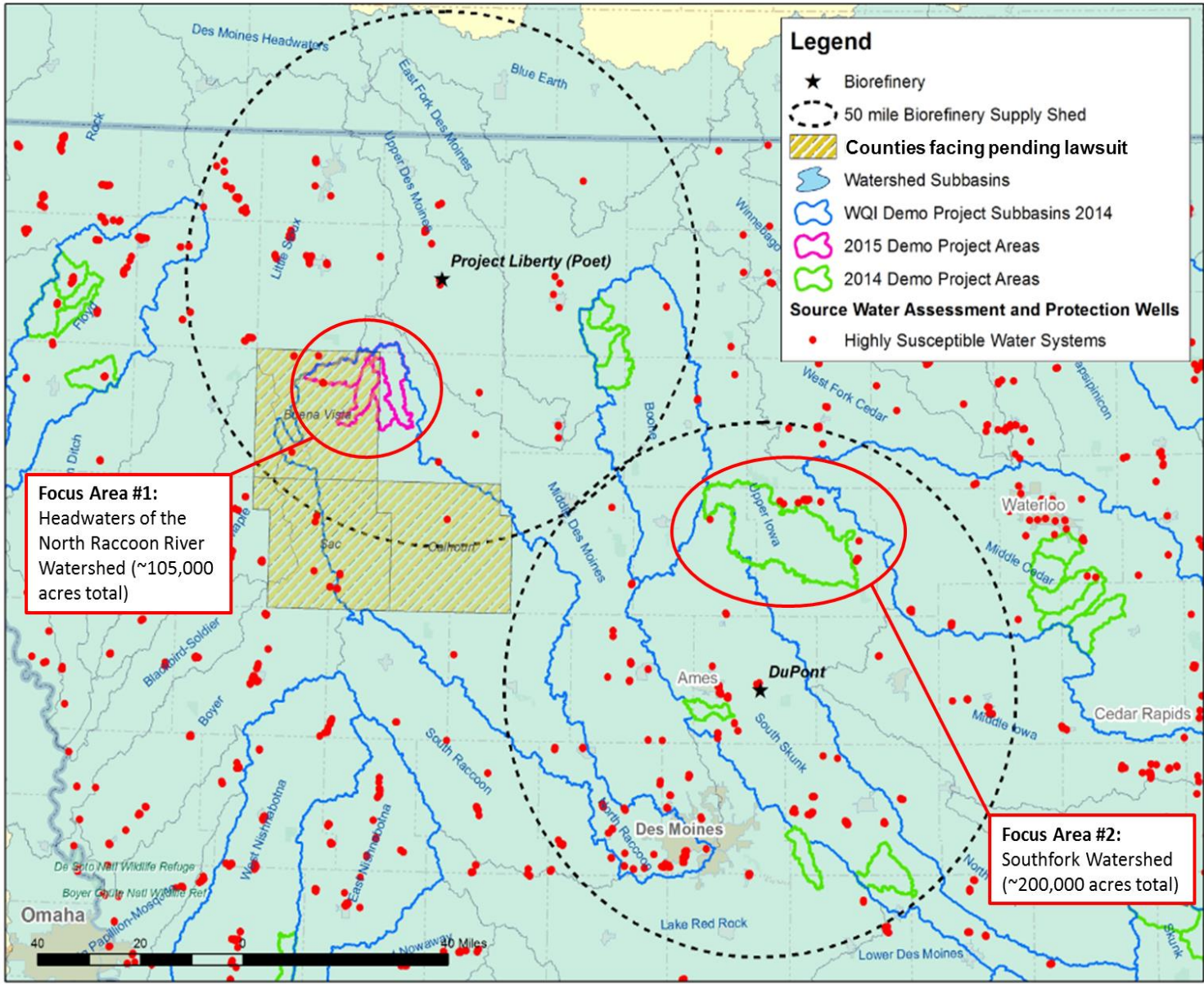
Biomass Toolbox

Biomass Market Access Standards (BMAS) Group

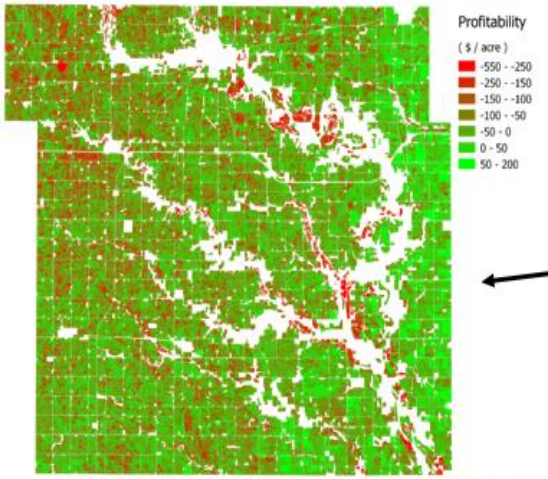
Targeted Watershed Areas

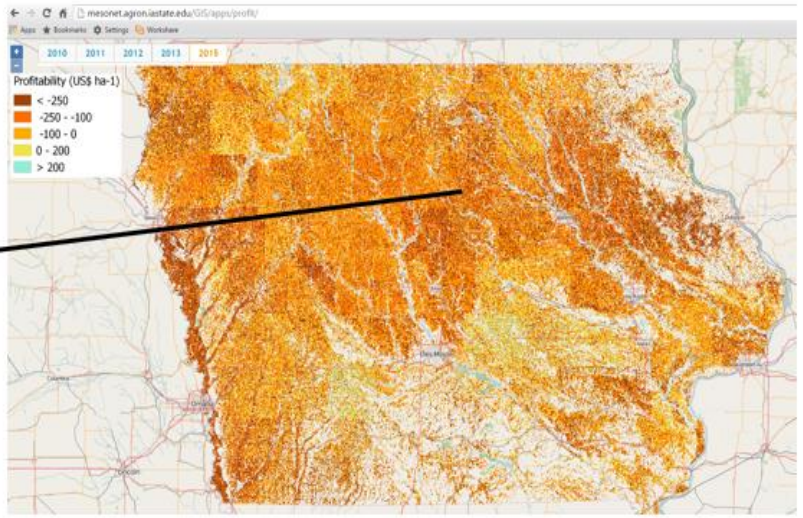
- Two biorefineries in start-up mode
- Iowa Nutrient Reduction Strategy Goals
  - Non-point
  - 41% less N
  - 29% less P
- ~$420 million spent in 2017 towards goals
- Better decision making tools needed for planning at all scales

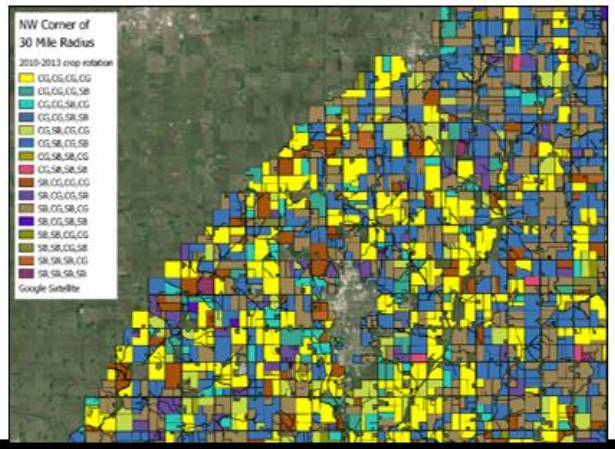


1 – Project Overview

Identifying the Impact and Opportunity







- Between 2-3 million acres annually at an expected loss
- Over $1B annually in misallocated working capital

Assembling/Advancing Key Pieces of the Puzzle

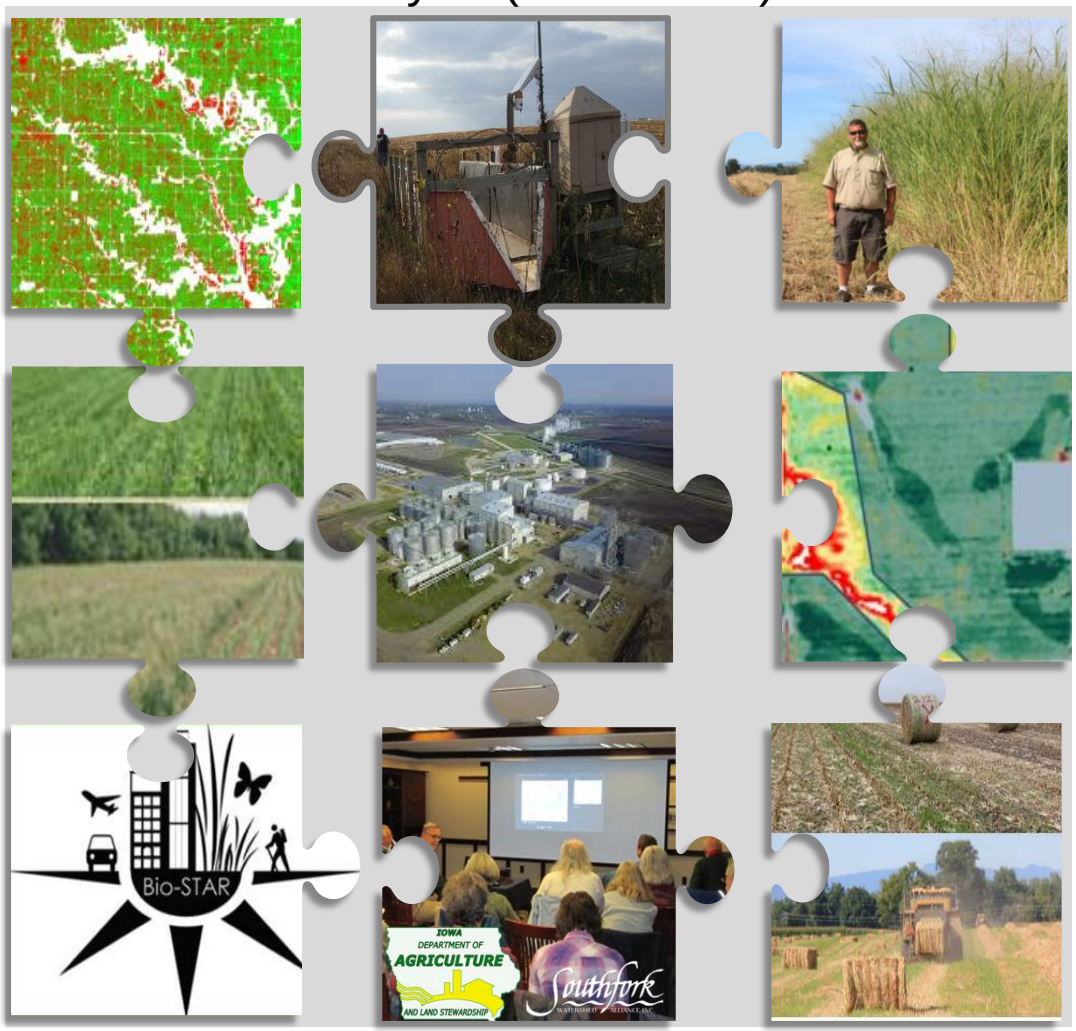
All linked to increased profits, biomass supplies, and key sustainability indicators.

Field Sampling
& Analysis (USDA ARS)

Regional Impact Modeling & Monitoring

Implementation of Conservation Practices (Cover Crops, Saturated Buffers, etc.)

Sustainability Indicators: Soil Health, Nutrient Run-off, Wildlife Biodiversity, GHG Emissions, Other



Perennial Grass for Conservation & Biomass Supply from Marginal Lands

Subfield Precision Business Planning (Profit-focused)

Sustainable Residue & Perennial Grass Harvest

Multi-stakeholder Outreach

2 - Approach (Management)

Overall project management and oversight is provided by Antares Group, with project tasks assigned to "subgroups" of experts.

Monthly technical & management meetings, *constant coordination*.

Project Tasks:

1. Multi-stakeholder Landscape Design Process
   Led by Antares Group, contributions by AgSolver & FDC Enterprises, Full Team
2. Assessment of Environmental Sustainability Indicators
   Led by ORNL, contributions by USDA-ARS, AgSolver, Penn State, & Antares Group
3. Assessment of Feedstock Supply and Logistics
   Led by INL, contributions by ORNL, Penn State, Antares Group, FDCE, ISU
4. Analytical Approaches for Subfield Analyses
   Led by AgSolver, contributions by Penn State, INL, Purdue, ANL
5. Targeted Feedstock and Environmental Assessment Data
   Led by USDA-ARS with contributions by Antares & FDC Enterprises

2 - Approach (Technical)

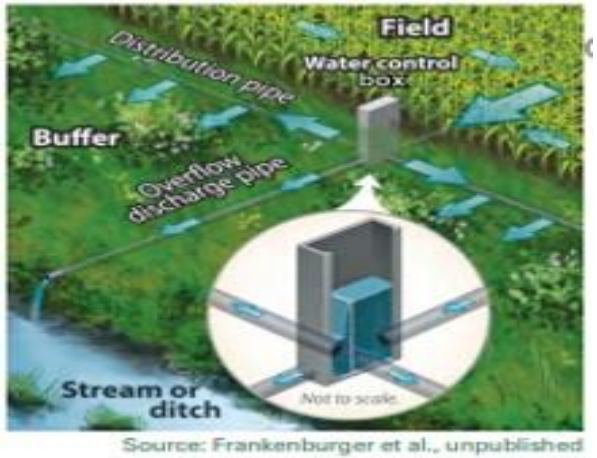
- Four primary biomass supply-related strategies:

Sustainable Stover Removal, without Cover Crops

Sustainable Stover Removal, with Cover Crops

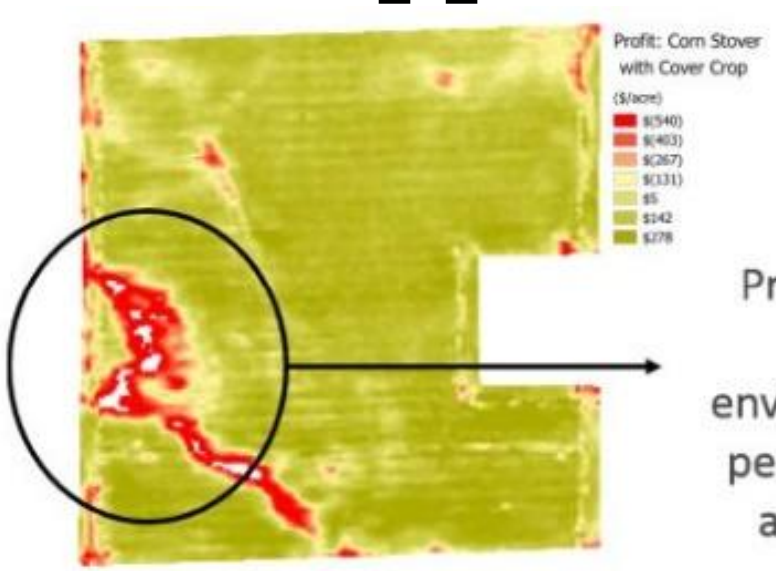
New/Increased Biomass Supply Potential

Perennial Grasses on Marginal Lands

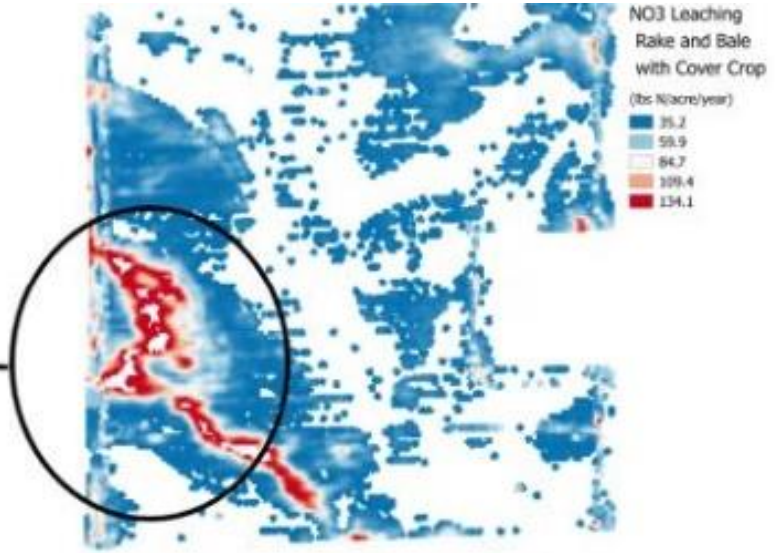


Saturated Buffers with Perennial Grasses

2 – Approach (Technical)

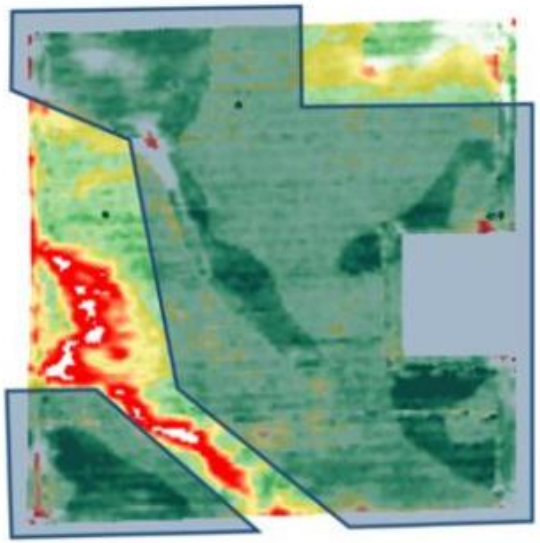


Profitability and environmental performance are linked

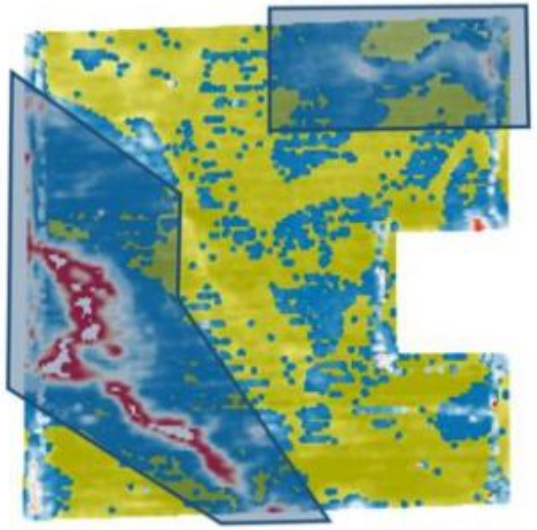


- Changing management practices to improve profitability, environmental performance, biomass supplies

Stover Removal Management Zones

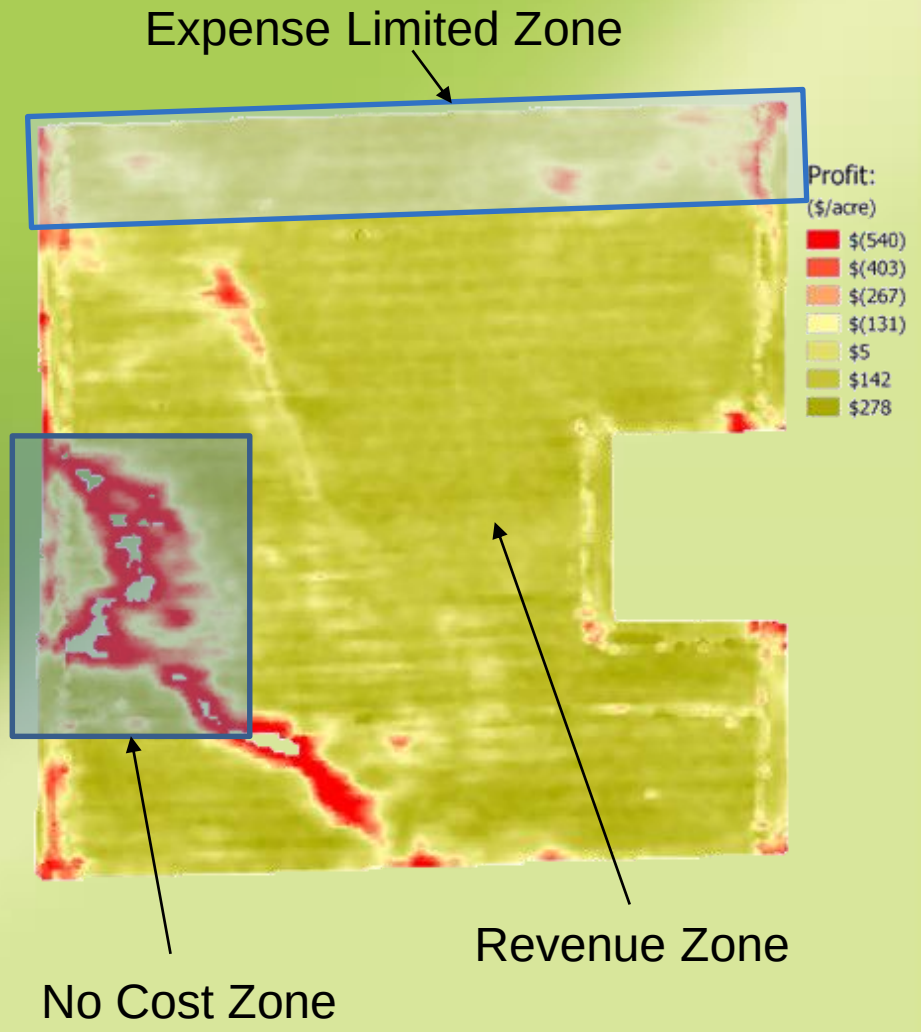


NO3 Leaching Mitigation Management Zones



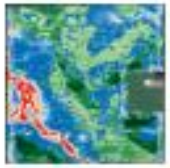
ROI Focused Agronomic Management

- Zonal Management to Increase Profits
- 143 acre field
- Estimated $5,000 of additional profit per year (reduced expenses only)
- Environmental benefits from changed management in vulnerable zones
- New perennial biomass supply
  - Estimated 45 to 60 tons new biomass supply
- Optimized sustainable harvest of ag. residues
  - Estimated *additional* 80 to 100 tons per year (sustainably)

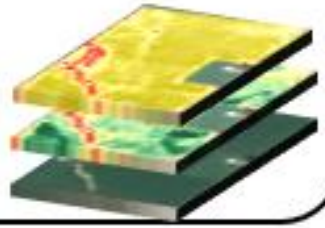


Field Work Process (Simplified)

Research Field Identified



Subfield **Profitability** Assessment Conducted



Land Management Changes Identified

Field Research Plans Developed

* Baseline Data Collection

Land Management Changes Implemented

Cover Crop

Switchgrass Establishment

Sustainable Stover Removal

(plus others by landowner preference)

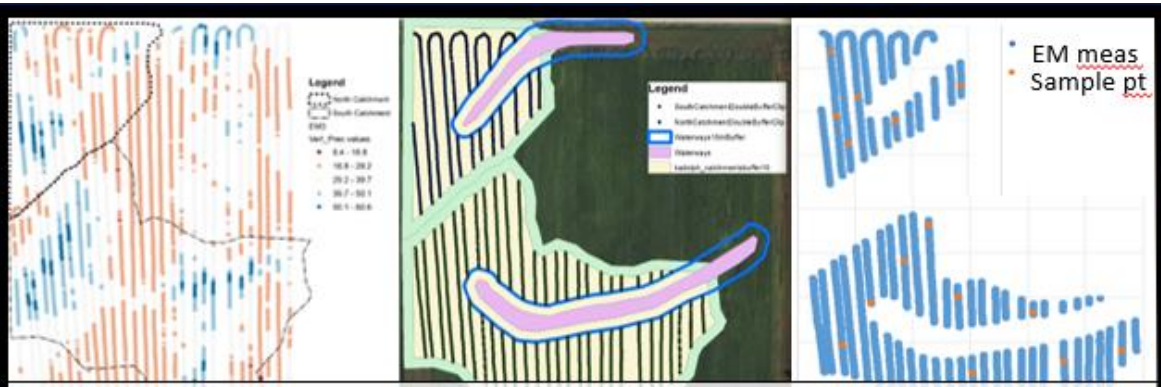
* Follow-Up Data Collection

Field Harvest Conducted

* Harvest Data Collection, Analysis, Reporting

* Sustainability Model and Data Analysis Tools are developed and coordinated with a Sustainability Reporting Platform

On-farm Landscape Approaches for Bioenergy Systems



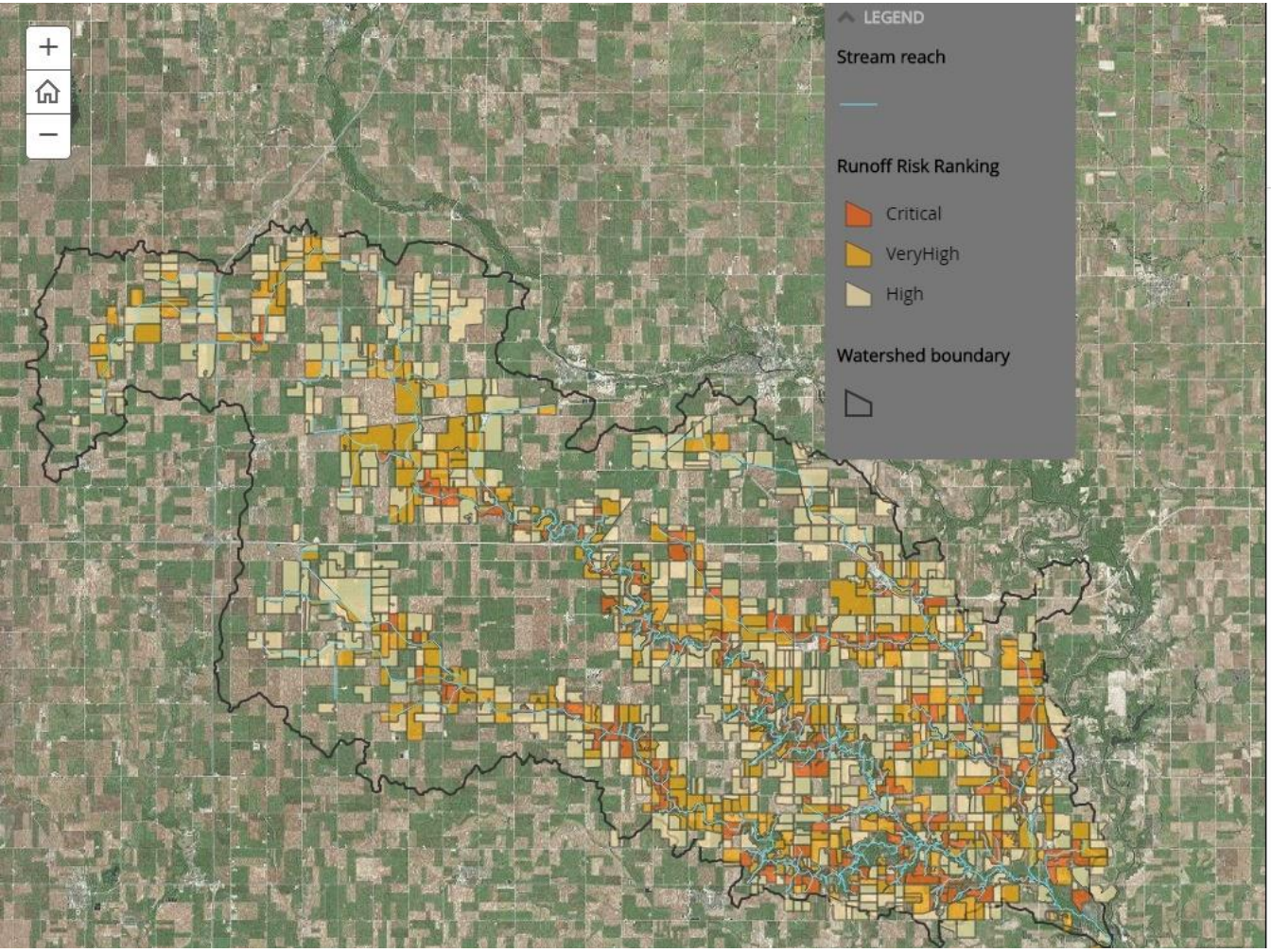
Rainfed corn: Stover removal, hydrology, water quality, soil health (IA) – Instrumented catchments, field studies, watershed models

Irrigated corn: Wind erosion, soil health (KS, CO) - Field studies, erosion models

Perennial grasses: Soil health and land use change impacts on marginal farmlands (IA) – Field studies, conservation management

Decision support tools: Sustainability for field, farm, and landscape (ACPF, AgSolver)

Landscape Analysis Tools



South Fork Watershed & The USDA

A Menu of Conservation Practice Opportunities in the South Fork of the Iowa River

greater may still be impacted by runoff, this is merely a suggestion.

Runoff Risk Assessment: Prioritize fields where multiple erosion control practices are most needed

Slope steepness	Close to stream? Yes		No
H	A	B	C
M	B	C	
L	C		

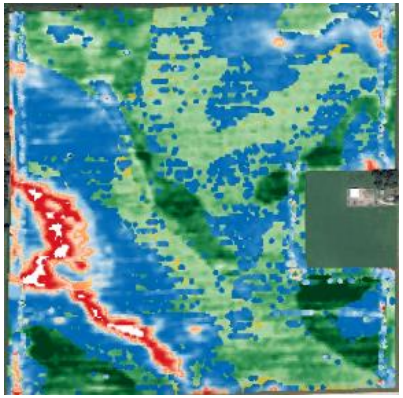
Drainage Water Management

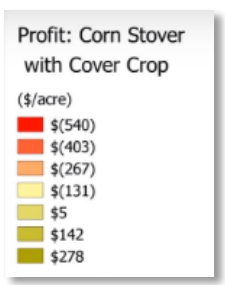
The inset map below shows a suitable area for drainage water management between the South Fork and Tipton Creek channels. This is a relatively flat area within the watershed, making it ideal for drainage management

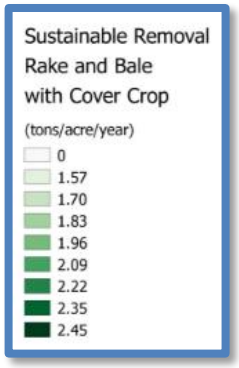
Tools such as the Agricultural Conservation Planning Framework (ACPF) are being used to Identify potential sites Landscape Design changes. In this case, the nutrient runoff risk is being assessed for the Southfork watershed.

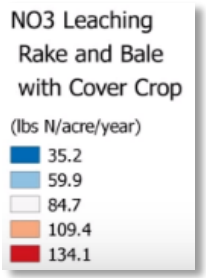
Straeter Header: Sustainable, Variable-Rate Harvest

- Real-time sustainability calculations in the field based on:
  - User inputs, corn yield, field conditions (soil type, slope, etc.)
- Reduces the need for overly conservative stover removal protocols that result in harvested stover yields of ~1 ton/acre









Credit: AgSolver / EFC Systems

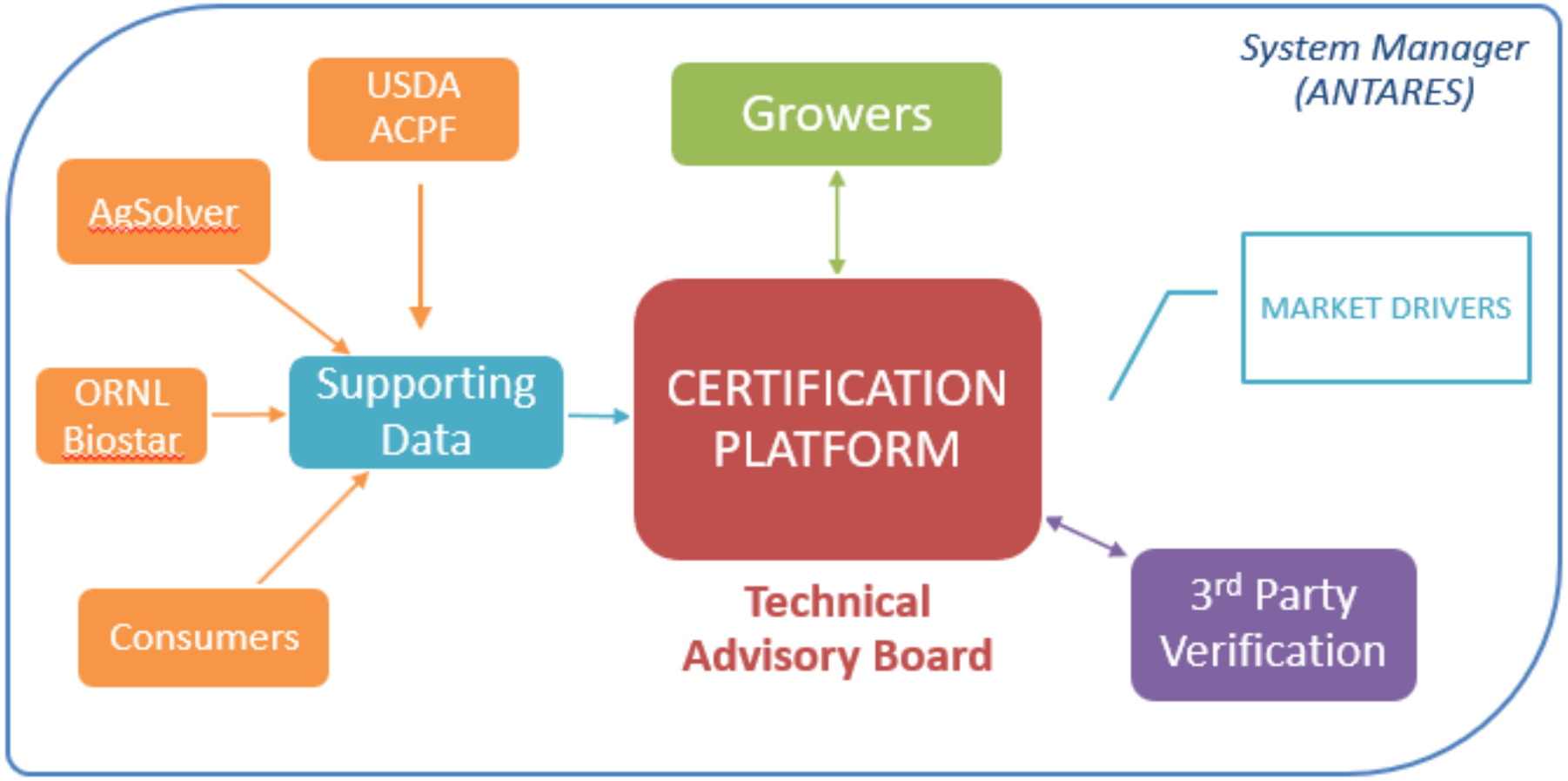
Advanced Data Analytics + Advances in Machine & Controls Technology and Feedstock Logistics = Improved: Sustainability, Biomass Supply Potential, Economics

Continuous Improvement System

- TurboTax-style Sustainability Certification Platform

BMAS
BIOMASS MARKET ACCESS STANDARDS

BMAS Interface Framework



Approach (Technical)

- Potential challenges to project success:
  - Short duration of project (plant, harvest, sample issues)
  - Securing the best possible harvest opportunities for R&D
  - Markets, policies, farm program rules
    - The stars are not all aligned to pull these strategies faster.
  - Changing inertia of established habits
    - Skepticism of “new” or “unknown”—cases must be compelling
- Critical success factors:
  - Sign-up & establishment of ~3,000 perennial grass acres
  - Up-take of tools in market/practice (e.g., PZM, ACPF)
  - Pilot program(s) needed to more fully test viability for perennial grass supply production (e.g., “SHIP”)

3 - Accomplishments

Assessments: On-farm catchments + 38 fields on 15 farms (IA), 3 research farms in KS & CO

New on-farm conservation practices for stover mgt (IA)

Saturated buffer network in Southfork watershed (IA)

Leveraging new studies on bioenergy switchgrass production potential on marginal lands; quantifying land use impacts on belowground root inputs; stakeholder meetings on soil health, conservation practices, bioenergy

3 - Accomplishments

- Stakeholder Engagement (an important "gathering place"):
  - For modelers and software/tool developers in need of a case study platform in the field for model testing and development
  - Software developers with precision agri-business and sustainability-related modeling and decision-making tools
    - AgSolver Profit-Zone-Manager (PZM) software
    - USDA ARS Agricultural Conservation Planning Framework (ACPF) Toolset
    - BioStar (ORNL)
    - Biomass Market Access Standards (BMAS) on-line biomass sustainability certification platform
    - Others (Cycles-PIHM, ORNL wildlife biodiversity model, NREL air quality modeling, GREET, INL & ORNL logistics modeling, Purdue, etc.)
  - Similar applications and needs in the Chesapeake Bay Watershed (through Penn State)

3 - Accomplishments

- Stakeholder Engagement (an important “gathering place”):
  - Farm/environmental sensor/equipment developers and researchers
    - ORNL Unmanned Aquatic Vehicle (UAV) for water quality measurements
    - DOE ARPA-E Smart Farm program (under development)
    - Variable rate corn stover harvesting system (New Holland)
  - Ag.-based researcher collaborations (e.g.,
    - ARS with the Soil Health Partnership (SHP)
    - Soil Health Institute (SHI)
    - NRCS Soil Health Division
    - FFAR (Foundation for Food and Agricultural Research) – Healthy Soils, Thriving Farms team)
  - Teamed on new 5-yr perennial crop research project, Next-Gen. Feedstocks for the Emerging Bioeconomy (led by U. of IL)

3 - Accomplishments

- Stakeholder Engagement (an important "gathering place"):
  - Landowners interested in participating in conservation, biomass supply, and learning about their land and new opportunities for improved management (survey of landowner feedback currently underway, Penn State/INL, landowner decision-making factors)
  - Recent discussions and presentations with California Air Resources Board (CARB), The Sustainability Consortium (TSC), NYSERDA
  - Recent IEA Bioenergy webinar was an example of project leveraging--speakers specifically mentioned the indicator prioritization with Iowa stakeholders as a case study & pointed listeners to the Dale et al. 2018 paper for more information
  - Ideas and linkages for field research and collaboration opportunities among team members and their colleagues
  - INL is a recipient of harvested biomass; for advanced R&D

3 - Accomplishments

- Stakeholder Engagement (an important “gathering place”):
  - Collaboration with state and local nutrient management efforts/programs, Federal farm program staff on new solutions
  - Collaboration with state and local organizations to obtain help to further their sustainability and economic development objectives

Straeter (Cornrower) Header Operation

- Enables higher sustainable stover removal rate, esp. w/ cover crop
- Low added O&M: <$1/ton
- Low Ash: ~5.5%
- In-field pre-processing possible
- Single-pass harvest to be developed

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For Videos: https://www.newhollandrochester.com/tag/cornrower/

Virginia Switchgrass Harvest

- 600 to ~ 2,000+ acres per year, 3 years and counting
- Used as proxy for Iowa “subfield” perennial grass harvest situation
- Part of existing switchgrass-to-boiler-fuel supply chain (very rare)

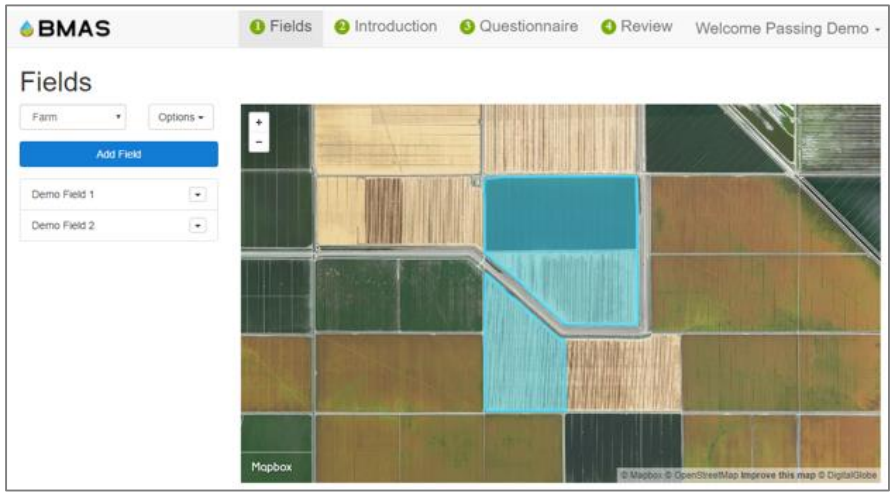
3 - Technical Accomplishments

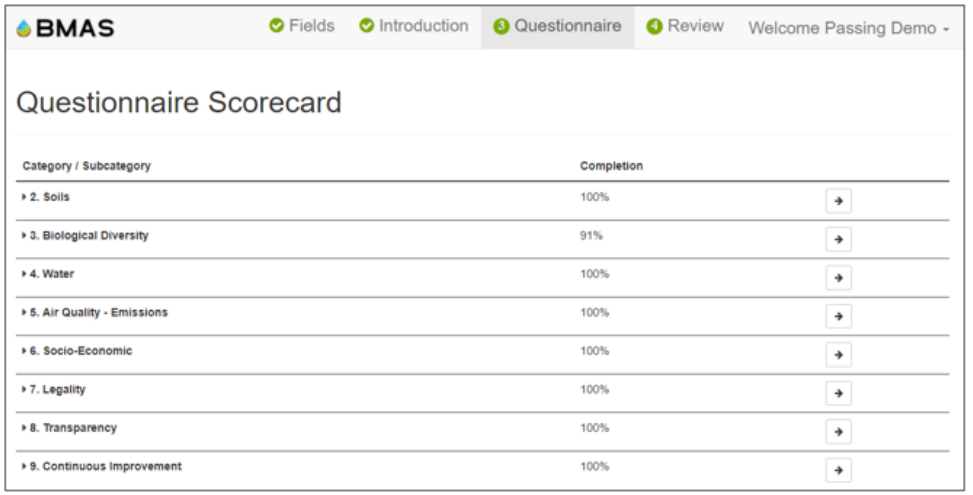
- Signed up and established ~3,000 acres of perennial grasses on marginal lands in IA, ahead of schedule (goal was 1,700)
- Field research planning complete (38 fields), initial (baseline) sampling done (Goal was 24 fields, USDA ARS)
- Monitored and completed annual harvest operations, analysis on-going by INL
  - Up to 2,000+ acres/yr in VA
  - Plot and field-scale corn stover harvests (fixed and variable rate)
- Watershed-wide ACPF opportunity mapping & on-line "storybook" done
- Initial SWAT modelling for nutrient run-off impacts completed for two targeted watersheds
- Saturated buffer installed in target watershed

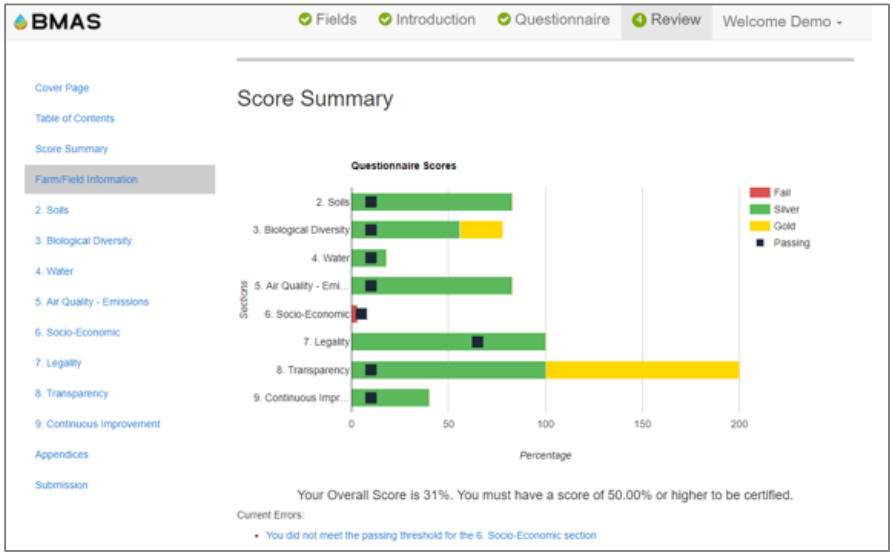
3 - Technical Accomplishments

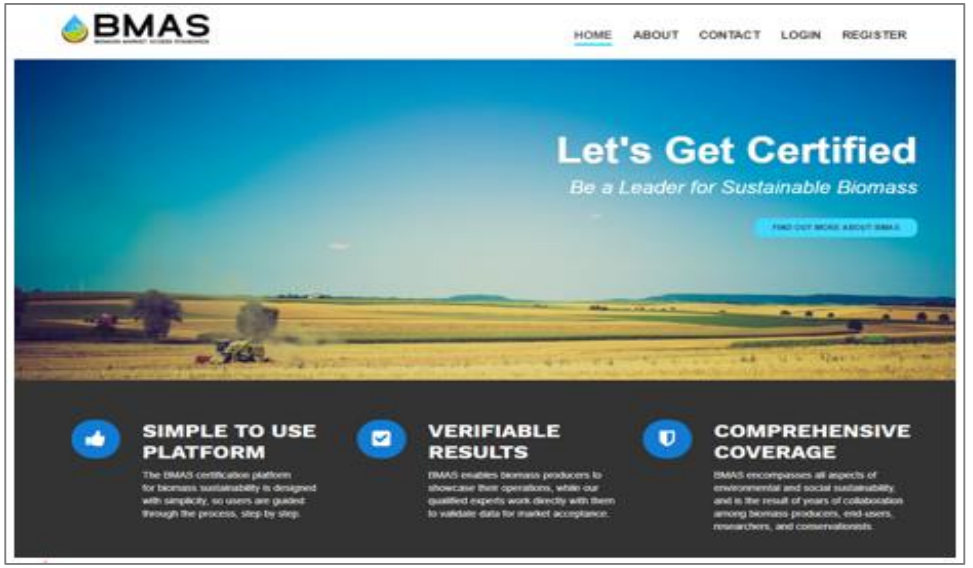
- Subfield environmental & profit analysis for entire state of IA (AgSolver)
  - Significantly more than initially planned
  - 48 different scenarios to date, x2 in 2019
- 17 papers published or in process to date
- Progress on web-based sustainability evaluation tool, ready to Beta-test
- Continued outreach with IA state and local groups on collaboration opportunities for strategy implementation
- Same concepts being used in Chesapeake Bay area
- Passed Stage Gate Review, March 2018
  - Funding in place for balance of project period

Web-based Sustainability Platform









4 – Relevance

- ***Goal:*** *Advance the state-of-the-art for sustainable bioenergy landscape design processes and provide a template for others to emulate.*
- ***Directly Supports BETO's Mission (from MYPP):***

Sustainability

- ✓ Advance scientific methods and models for measuring and understanding bioenergy sustainability across the supply chain
- ✓ Disseminate practical tools that support analyses, decision making, and technology development
- ✓ Identify, develop, and promote practices that enhance sustainable bioenergy outcomes
- ✓ Develop landscape design approaches that increase bioenergy production while maintaining or enhancing ecosystem and social benefits.

Strategic Analysis

- ✓ Ensure high-quality, consistent, reproducible, peer-reviewed analyses
- ✓ Develop and maintain analytical tools, models, methods, and datasets to advance understanding of bioenergy and related impacts
- ✓ Convey results of analytical activities to a wide audience.

- ***Project is focused on two high-impact herbaceous feedstocks***
  - *Corn stover, perennial grasses*
- ***Tech/Information Transfer:***
  - *AgSolver tools are available through EFC Systems for subscription*
  - *USDA ARS's ACPF is available on the web*
    - *Extensive user training has already been developed and performed*
  - *17 directly funded or leveraged publications to date (or in process)*

5 – Future Work

- Tableau data visualization tool to facilitate scenario analysis using state-wide AgSolver subfield analysis results
  - SWAT modeling of biomass production scenarios for target watersheds (nutrient run-off impacts)
  - Wildlife biodiversity modeling
  - Biomass supply impact analyses
- Baseline perennial grass field sample analysis and reporting, repeat in final year
- Annual controlled plot and field-scale work and monitoring for stover removal replications
- Annual switchgrass and corn stover harvest operations, data collection, analysis, reporting
- Case study examples (5) for key strategies demonstrated
- Beta-testing of on-line biomass sustainability evaluation system
- Landscape Design “Handbook”

Summary

1. **Overview –** Goal is to develop and demonstrate new tools and approaches for planning and implementing sustainable landscape design strategies.

2. **Approach –** Project combines advanced agronomic analysis, leveraging precision agricultural data and leading data sources, science-based models and tools, a rigorous field research and demonstration program, and a thorough and continuous stakeholder outreach and team-building approach.

3. **Technical Accomplishments/Progress/Results –** ~3,000 acres of established perennial grasses; thousands of acres per year of harvest and data acquisition, with related analysis by INL; completed a thorough research field selection process aimed at achieving maximum new, publishable scientific value; completed baseline soil sampling for all research fields; extensive subfield agronomic analysis completed for entire state of IA.

4. **Relevance –** Directly support and addresses many sustainability and analysis objectives within BETO's mission. Broad and credible team and stakeholders, including key industry and state government stakeholders is evidence of project relevance.

5. **Future work –** Multi-year field sampling, lab analysis, and reporting for key sustainability indicators; annual corn stover and perennial grass harvest and anaaysis; case study examples (5) for key landscape design strategies demonstrated; Beta-testing of on-line biomass sustainability evaluation system; data visualization and scenario-development interface using extensive state-wide sub-field agronomic analysis results; Landscape Design "Handbook".

END OF PRESENTATION: ADDITIONAL SLIDES

Responses to Previous Reviewers' Comments

- **Significant Questions/Criticisms from 2017 Peer Review Report:**
  - Reviewer Comment: This is, even when pursued on a relatively small scale, a very expensive undertaking (something on the order of $12 million), though one of the strengths of the approach is leveraging contributions from other sources.
  - Response: Our team recognizes the importance of and magnitude of this amount of funding, and the importance of putting those funds to productive and meaningful use with practical, actionable outcomes. We also recognize that this project is very important to the Analysis and Sustainability efforts of BETO. As such, our team is seeking every available opportunity to further leverage this funding with supplemental federal, state, and private funding to enable our team to extend the reach, implementation, and applicability of our efforts. We are also continuing to reach out to other researchers and interested organizations to maximize the collaboration from our project, both to help their efforts where possible by involving them in our project and to allow our team to benefit from their efforts. These collaboration and team building efforts have been extremely successful to date.

    While $12 million is a large amount of funding, it is also helpful to put that into context with a few other important metrics: 1) the two biorefineries we are collaborating with (POET and DuPont) are targeting to procure a total of about 650,000 tons of biomass per year, resulting in annual biomass procurement costs of about $52 million (@$80/ton), or about $260 million over a 5-year period that's equivalent in duration to this project's duration (hundreds of refineries of this size would be needed to reach the future targets of the Renewable Fuel Standard); 2) the BETO program and ORNL have recently published the "2016 BILLION-TON REPORT--Advancing Domestic Resources for a Thriving Bioeconomy", which projects hundreds of millions of tons per year of supplies needed in the future from agricultural residues and herbaceous energy crops in order to approach or achieve the vision described in that study (500 million tons/yr x $80/ton = $40 billion/yr in biomass supply value from the types of resources we are focusing on in this project), and 3) in Table 2.6 of the 2016 BILLION-TON REPORT, based on USDA census data there were less than 3,000 acres of energy crops harvested in 2012 producing less than 12,000 dry tons of biomass. This project has already contracted more than that amount of acreage to be established as part of our research and demonstration efforts. In the context of the above considerations, the funding dedicated to this project is modest and necessary. It is incumbent on our team to utilize this project as an agent of change, to: 1) demonstrate opportunities for landowners and farmers to add bioenergy crops into their management practices in ways that are economically preferable and beneficial to their operations, 2) develop new and improved management and decision-making tools to facilitate better targeting of marginal farmland for energy crop production and improved environmental performance, 3) identify policy issues and options for . . . .

Responses to Previous Reviewers' Comments

- **Significant Questions/Criticisms from 2017 Peer Review Report:**
  - (continued from previous page) . . . . facilitating improved value from conservation and energy crop incentive programs to enable greater future sustainable biomass supply production; 4) develop high-quality, publishable scientific field monitoring results and reports to document the merits of the management approaches and alternatives pursued in this project; 5) demonstrate, monitor, and report on equipment-related advances and issues associated with the agricultural residue and perennial herbaceous energy crop establishment and harvesting activities and strategies pursued in this project; and 6) create a template that can be deployed in other areas of the county (at much lower costs than this first project) to help implement these landscape design and management approaches to help support a growing bioeconomy while improving environmental services in project areas. Several members of our team are already engaged in efforts to deploy similar tools and techniques for planning and implementation efforts in the Chesapeake Bay Watershed area.
  - Reviewer Comment: It will be important to understand farmers' own choices that reveal information about what works in practice. Understanding and accounting for this will be critical to ensuring the tools developed will be as practical as possible.
  - Response: As part of our contracts with participating landowners, they have agreed to interact with our team to provide feedback on their choices, preferences, reasoning, criticisms or skepticism, and experiences with our team and the management practices they have made in collaboration with our project. We have powerful feedback solicitation tools and expertise (ThinkTank) involved with this project through Idaho National Lab and the USDA Agricultural Research Service, and we plan to deploy those tools to solicit feedback from key stakeholders as part of the project's activities. We will likely deploy a combination of those tools and face-to-face, one-on-one interactions to solicit this type of feedback throughout the project period. We are currently performing a round of face-to-face interviews with over 30 landowners who have participated in project-related activities to date, with the purpose of understanding their priorities for decision-making with respect to this project's objectives.

Responses to Previous Reviewers' Comments

- **Significant Questions/Criticisms from 2017 Peer Review Report:**
  - Reviewer Comment: It will be critical to understand what the minimum size a subfield needs to be so that a change in management practice is practical as well as profitable.
  - Response: This is part of our team's approach and scope of work. In some cases, where an unprofitable subfield is identified, the size or location of that subfield will not be practical for establishing an energy crop. Those areas may be best suited for conversion to a conservation practice (CRP, establishing a grass waterway or field border, etc.), whether enrolled in a government program or not. The key point is that the identified subfields are unprofitably farmed year after year, and it is worthwhile for the farmer to consider a management change that will limit or eliminate those losses (the management change could be as simple as reducing fertilization and seeding expenses in the identified unprofitable areas). Part of Iowa State University's scope of work for the project is to identify factors associated with whether or not a particular subfield would be profitable and practical to convert to a perennial energy crop. Ultimately, the farmer will consider management changes and change options based on their specific circumstances and preferences.
  - Reviewer Comment: It's not worth spending millions of dollars on planning to make hundreds in farming, and so, again, it's crucial to have a sense of how general the results being developed will prove to be.
  - Response: Developing the software and the underpinning modelling, calibrations, field demonstrations, field monitoring, data collection, and scientific reporting and publications is expensive. Those expenses are not necessary on an ongoing basis. Once developed, application of the tools is very affordable because it is a matter of defining field boundaries, collecting field-specific equipment data (where available), setting up the model parameters, and running a computer model—this is performed by a trained expert working on behalf of the farmer. AgSolver already offers a money-back policy on their advisory services—if the value of the misallocated capital in a farming enterprise does not exceed the costs of AgSolver's fee, the fee is refunded. The fee for a one-year software license with technical support, allowing agri-business analysis for an entire farm enterprise (could be thousands of acres), is relatively nominal (several thousand dollars per year).

Previous Reviewers' Comments

- **Highlights from any Go/No-Go Reviews (From March 2018, Stage Gate Review)**
  - Reviewers at the March 2018 Stage Gate Review provided the following positive feedback regarding ORNL's contributions to this project: "The process for prioritizing and choosing relevant sustainability indicators is outstanding. The journal article published by Dale et al (provided to us during the review meeting) on this process and its outcomes is an important contribution to the literature on sustainability metrics. The team has gone to extraordinary and yet efficient means to engage a large number of organizations and stakeholders who would be impacted by the development of sustainable bioenergy and product supply chains in the targeted region of Iowa by taking advantage of multiple venues during 2015 and 2016. The analysis of the stakeholder feedback is intelligently and cogently presented, and is a model for others who wish to adopt a valid stakeholder engagement process." (ORNL, Parish)
  - The project aligns well with the FOA, and the proposed deliverables have promise to provide significant value to stakeholders involved, as well as the agricultural sector more generally. The breadth of stakeholders engaged is impressive, and appropriate means are being used to gather needs and feedback. The data, tools, and insights developed should be transferrable to food systems in general, not just biofuel crops.
  - This project is responsive to the changing bioeconomy. It continues to be relevant to both the FOA and stakeholders, despite loss of partners Abengoa and DuPont during the project period. The work being conducted in all tasks should help to enable the next generation of industry based on non-food crops while increasing the value and sustainability of commodity grain crops.
  - The tools, training and demonstration activities address the needs of stakeholders in the local landscape who want to proactively design their landscape for a sustainable future. The project leaders have assembled an outstanding team covering all of the required areas of expertise, representing contributions from government and academic researchers and, importantly, private sector entrepreneurs and farmers. This will ensure that its products and deliverables will be useful and relevant to both DOE and stakeholders.
  - The project has a high degree of focus on and commitment to achieving its goal of enabling design at the landscape level for a community-wide sustainable future. Much of this is due to the evident passion of the leadership team at Antares and at USDA. It is unfortunate that there is not a place in the review form to acknowledge this more intangible aspect of the project. While the project management we observed is clearly strong, it is the transformative nature of the project leadership that is found to be most exciting.

Previous Reviewers' Comments

- **Highlights from any Go/No-Go Reviews (From March 2018, Stage Gate Review)**
  - It is also very rewarding to see DOE's Bioenergy Technology Office take such a comprehensive and proactive approach to addressing the role that bioenergy can and must play in sustainable development. In this project, it is a demonstration on the part of BETO to take concrete steps to ensure its sustainability. Maintaining this commitment will always be difficult, especially in the face of increasing budget pressures. It is the hope that BETO and EERE management will continue to support these efforts, and encourage them to push for greater attention to the comprehensive challenges of sustainable development in the rest of its technology programs.
  - This task represents excellent leverage of the USDA soil science infrastructure and is conducting high-quality work at a scale that is likely to provide the first clear understanding of soil impacts from landscape design by using a paired field approach (powerful experimental design conducted at a real-world scale) and detailed soil and modeling analysis. The science is being conducted in close connection with other task, team and stakeholder members, ensuring broad dissemination and use of task findings.
  - The team presented an excellent and concise overview of progress on initial sampling efforts for baselining environmental indicators.
  - The AgSolver tool appears to offer an unprecedented level of granularity (approximately 9 square meter unit) in the assessment of crop field performance measured as profitability (return on investment). Recent efforts by USDA ARS's Ag Conservation Planning Framework team have resulted in what will ultimately be a valuable web tool that offers individual farmers the ability to explore specific opportunities within their farm operations to improve water quality in the context of the larger watershed. Used together, these two tools will allow farmers to balance trade-offs and identity win-win opportunities for increased profitability and long term stewardship of their watershed.
  - Almost more than any other project seen coming out of BETO, this project demonstrates a high degree of integration with other current and past research activities, particularly with regard to the extensive efforts at USDA locally (in the targeted landscape study area). The project is well-managed, and its leadership has developed an exceptional atmosphere of collaboration and commitment to the goals of the project. An intangible and yet important strength of this project is the level of energy and passion that permeates the team. This starts at the "top", with the PIs, who have communicated a powerful vision for the work. The level of cooperation between USDA and DOE is extraordinary.
  - Finally, a word of caution to the modelers and analysts—keep your eye on the prize. In this case that prize is a tool or set of tools that truly enables the users of these tools to efficiently and effectively make decisions that move the dial on sustainable development of the bioeconomy. No challenge is more difficult than this for analysts. There is a hard-to-achieve balance between rigor and robustness and the power and utility of simplicity. It is encouraged that you to spend some time planning for how these analytical tools will come together to meet the various needs of multiple end-users, from the technologically savvy

Previous Reviewers' Comments

- **Highlights from any Go/No-Go Reviews (From March 2018, Stage Gate Review)**
  - The one area where this project needs to focus more rigorously on is the ultimate usability of the decision support tool they are developing. This requires having the clearest possible understanding of the audience for this tool. It will be important to work throughout the modeling and development process WITH these users to ensure that this tool will be a catalyst for, and not obstacle to, good landscape design.
  - Finally, a word of caution to the modelers and analysts—keep your eye on the prize. In this case that prize is a tool or set of tools that truly enables the users of these tools to efficiently and effectively make decisions that move the dial on sustainable development of the bioeconomy. No challenge is more difficult than this for analysts. There is a hard-to-achieve balance between rigor and robustness and the power and utility of simplicity. It is encouraged that you to spend some time planning for how these analytical tools will come together to meet the various needs of multiple end-users, from the technologically savvy user who will appreciate and actually make use of the details to the user whose focus is necessarily broader.
  - The following comments are meant to further enhance the value delivered by the program… (1) The program needs a figure and a story that ties all of the deliverables together and shows them as a system, (2) More inclusion of national and international NGOs, like the ones involved in BMAS, might help diffuse knowledge to other sectors and countries, (3) Third party software developers should be invited to table now, as they can further the quality and adoption of better software tools, beyond that the current program can fund, (4) Build monetization methods into the environmental assessments as much as possible, (5) use operations research modeling to explore tradeoffs (beyond the MCDM model), (6) Final report should contain recommendations for broad adoption by growers.

Publications, Patents, Presentations, Awards, and Commercialization

17 Publications published, accepted, or under revision to date. (12 from ARS, 3 from ORNL, 2 from INL)

Directly Funded Publications:

- Dale et al. (2018) Bridging biofuel sustainability indicators and ecosystem services through stakeholder engagement. Biomass and Bioenergy 114:143-156.
- Jager HI and Kreig JAF (2018) Designing landscapes for biomass production and wildlife. Global Ecology and Conservation 16:e00490.
- Sharma B, Clark R, Hilliard MR, Webb EG (2018) Simulation modeling for reliable biomass supply chain design under operational disruptions. Frontiers in Energy Research 6:100. doi: 10.3389/fenrg.2018.00100
- Karlen DL, JF Obrycki. 2018. Measuring rotation and manure effects in an Iowa farm soil health assessment. Agron. J. 111:63-73. doi:10.2134/agronj2018.02.0113
- Obrycki JF, DL Karlen. 2018. Optimizing Iowa land use: Past perspectives for current questions. J. Soil Water Conserv. 73:693-704. doi: 10.2489/jswc.73.6.693
- Obrycki JF, DL Karlen, CA Cambardella, JL Kovar, SJ Birrell. 2018. Corn stover harvest, tillage, and cover crop effects on soil health indicators. Soil Sci. Soc. Am. J. 82:910-918. doi:10.2136/sssaj2017.12.0415
- Hansen, J.K, Nair, S.K., Roni, M.S., Hartley, D.S., Griffel, L.M., Vazhnik, V. & Mamun, S. (2019). Herbaceous feedstock supply chain cost risk assessment. Submission to Biomass and Bioenergy.
- Griffel, M., Vazhnik, V., Hartley, D., Hansen, J., Richard, T. (2019). Machinery maneuvering efficiency and perennial crops: field shape complexity defines the efficiency. Manuscript in development.

Publications, Patents, Presentations, Awards, and Commercialization

Leveraged Publications (co-author is a member of our project team and the publication is related to our project activities and subject matter, but the publication was not directly funded by this project):

- Stewart CE, D Roosendaal, AJ Sindelar, E Pruessner, VL Jin, MR Schmer. Does no-tillage mitigate stover removal in irrigated continuous corn? A multi-location assessment. Soil Sci. Soc. Am. J. Accepted Feb 13, 2019.
- Dien BS, Mitchell RB, Bowman MJ, Jin VL, Quarterman J, Schmer MR, Singh V, Slininiger PJ. 2018. Bioconversion of pelletized big bluestem, switchgrass, and low-diversity grass mixtures into sugars and bioethanol. Frontiers Energ. Res. 6: Article 129. doi.org/10.3389/fenrg.2018.00129
- Ibrahim VE, SL Osborne, TE Schumacher, WE Riedell. 2018. Corn residue removal effects on hydraulically effective macropores. Comm. Soil Sci. Plant Anal. 49:1491-1501. doi.org/10.1080/00103624.2018.1464187
- Jin VL, MR Schmer, CE Stewart, B Mitchell, CO Williams, BJ Wienhold, GE Varvel, RF Follett, J Kimble, KP Vogel. Perennial feedstocks on marginally-productive land contribute to climate mitigation goals. Science Advances. Revision pending.
- Locker CR, Laurenzi IJ, Torkamani S, Jin VL, Schmer MR, Karlen DL. 2019. Field-to-farm gate greenhouse gas emissions from corn stover production in the Midwestern U.S. Journal of Cleaner Production. Accepted February 2019.
- Sindelar M, Blanco H, Jin VL, Ferguson R. 2019. Cover crops and corn residue removal: impacts on soil hydraulic properties and their relationships with carbon. Soil Sci. Soc. Am. J. doi:10.2136/sssaj2018.06.0225
- Sindelar M, Blanco H, Jin VL, Ferguson R. 2019. Do cover crops and corn residue removal affect soil thermal properties? Soil Sci. Soc. Am. J. Accepted November 2018.
- Stetson SJ, RM Lehman, SL Osborne. 2018. Corn residue particle size impacts soil surface properties. Agric. Environ. Lett. 3:180004 doi:10.2134/ael2018.01.0004.
- Stewart CS, Roosendaal DL, Sindelar A, Pruessner E, Jin VL, Schmer MR. 2018. Soil property changes from stover removal under irrigation: a multi-location assessment. Soil Science Society of America Journal. In Review.
- Wegner BR, SL Osborne, RM Lehman, S Kumar. 2018. Seven-year impact of cover crops on soil health when corn residue is removed. BioEnerg. Res. 11:1-9. doi.org/10.1007/s12155-017-9891-y.

Web-based Sustainability System

- Concept origination:

Council for Sustainable Biomass Production

- CSBP was multi-stakeholder organization established in 2007
- Science based voluntary sustainability standard for biomass growers and bioenergy producers
- Consensus document - *Standard for Sustainable Production of Agricultural Biomass*
  - Developed by US industry, environmental, socio-economic and producer interests 2007 through 2012
  - Certification program and verification mechanism

COUNCIL ON SUSTAINABLE BIOMASS PRODUCTION

Web-based Sustainability System

- Contributors to CSBP Agricultural Standard, 4+ yrs

- **BIOMASS PRODUCERS**
  - ArborGen, LLC
  - BioResource Management, Inc.
  - Ceres, Inc.
  - Genera Biomass LLC
  - Mendel Biotechnology, Inc.
  - Monona Farms/Switchgrass for Bioenergy
  - Prairie Lands Bio-Products, Inc.
  - Show Me Energy Cooperative
- **BIOMASS CONSUMERS**
  - DuPont Danisco Cellulosic Ethanol
  - Duke Energy
  - Chevron
- **ENVIRONMENT**
  - Environmental Defense Fund
  - National Wildlife Federation
  - Natural Resources Defense Council
  - The Nature Conservancy
  - Theodore Roosevelt Conservation Partnership
- **SOCIO-ECONOMIC**
  - American Forest Foundation
  - Association of Fish & Wildlife Agencies
  - Center for BioEnergy Sustainability, ORNL
  - Energy Biosciences Institute, U of I
  - Great Plains Institute
  - Institute of Renewable Natural Resources, Texas A&M
  - National Association of State Foresters

Technical Advisors: USDA, US DOE Biomass Program, ANTARES Group

Web-based Sustainability System

- Framework for the CSBP Standard:

PRINCIPLES - key elements of sustainable biomass production

1. IRMP
2. Soil Quality
3. Biological Diversity
4. Water Quality & Quantity
5. Climate Change
6. Socio-Economic Well-Being
7. Legality
8. Transparency
9. Continuous Improvement

Each PRINCIPLE has associated CRITERIA, with INDICATORS to evaluate participant activities or compliance.