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

U.S. Department of Energy (DOE)
Bioenergy Technologies Office (BETO)
2017 Project Peer Review,
March 9, 2017
Denver, CO

Analysis & Sustainability Session

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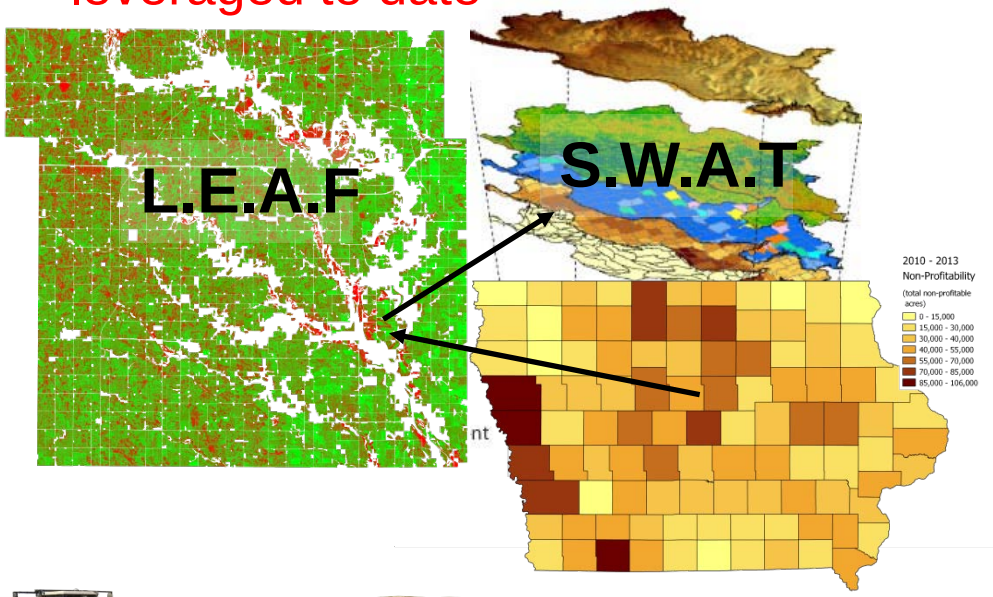
Landscape Design for Sustainable Bioenergy Systems

Goal Statement:

The team will work with growers and biomass end-users to utilize subfield agronomic models to target areas within existing cellulosic ethanol feedstock supply sheds to build baseline datasets, implement conservation practices, monitor key environmental indicators, and monitor the environmental and economic impacts to the watersheds and the biomass supply chain. (to enable future biomass supply systems)

Total Project Budget	$12,000,000
DOE Funds Awarded	$9,000,000
Applicant Cost Share	$3,000,000

$12.25 million additional leveraged to date



Quad Chart Overview

Timeline

- Project start date: April 1, 2016
- Project end date: March 31, 2021
- Percent complete: 16.8%

Budget

	Total Costs FY 12 –FY 14	FY 15 Costs	FY 16 Costs	Total Planned Funding (FY 17-Project End Date)
DOE Funded			$1,046,870	$ 7,953,130
Project Cost Share				
Iowa Dept. of Ag. & Land Stewardship (IDALS)			$ 447,734	$ 1,552,266
AgSolver			$ 7,500	$ 117,500
FDC Enterprises			$ 54,159	$ -
Iowa State University				$ 125,000
Poet-DSM				$ 500,000
Purdue University				$ 14,962
Pennsylvania State University				$ 178,985

Barriers

- **St-C**. Sustainability Data across the Bioenergy Supply Chain
- **St-D**. Implementing Indicators and Methodology for Evaluating and Improving Sustainability
- **St-E**. Best Practices and Systems for Sustainable Bioenergy Production
- Profitably, sustainably enabling biomass supplies

Partners

IDALS (18%)
Antares Group (17%)
USDA Agricultural Research Service (17%)
FDC Enterprises (13%)
Idaho National Lab (10%)
Pennsylvania State University (6%)
AgSolver (5%)
Oak Ridge National Lab (4%)
Poet-DSM (4%)
Argonne National Lab (2%)
Purdue University (2%)
Iowa State University (1%)
Scientific Certification Systems (SCS) (1%)

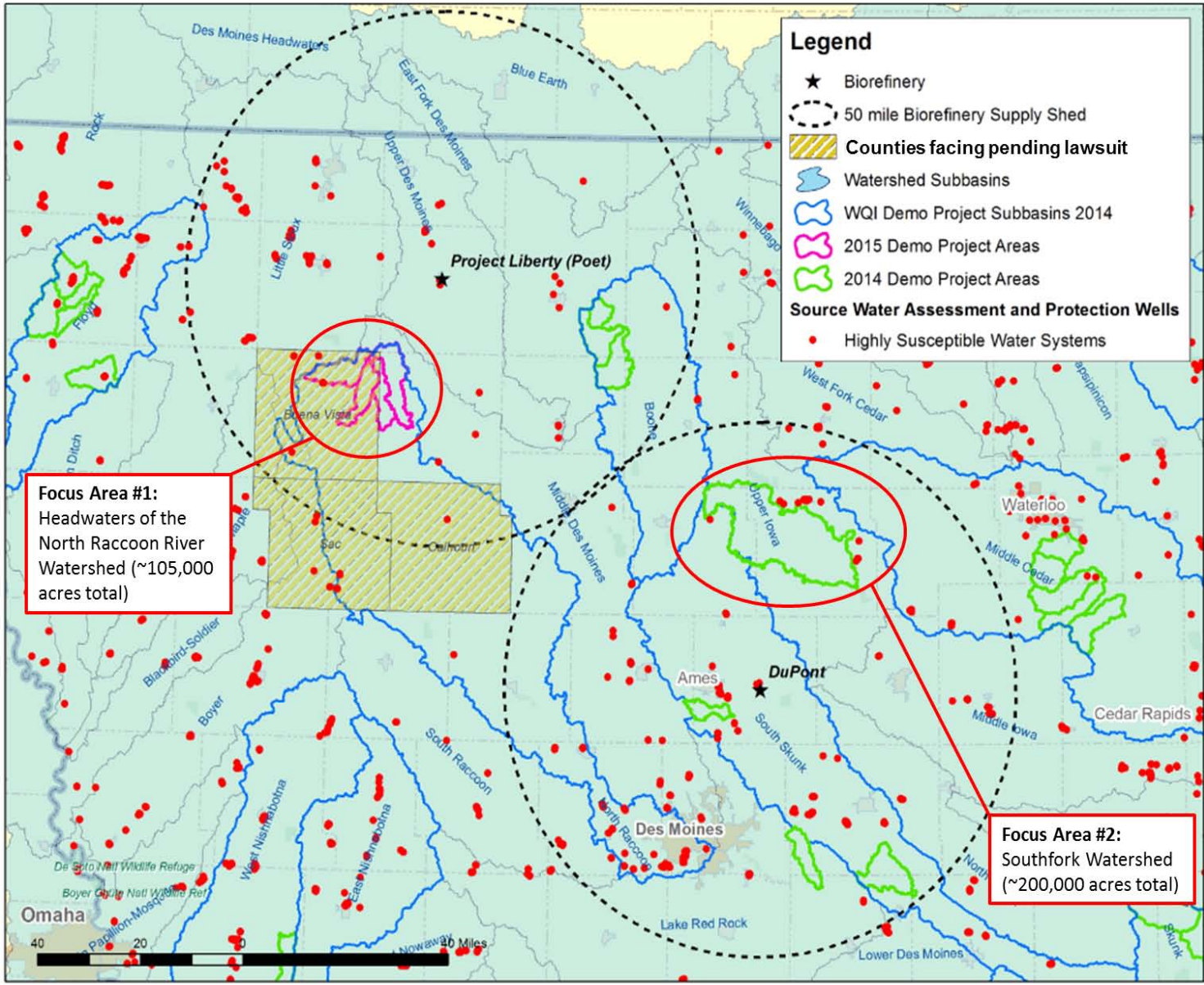
1 - Project Overview

Required Areas of Focus:

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

Targeted Watershed Areas

- Two biorefineries in start-up mode
- Iowa Nutrient Reduction Strategy Goals
  - Non-point
  - 41% less N
  - 29% less P
- ~ $115 million spent in 2015 towards goals
- Better modelling capabilities needed for planning



2 - Approach (Management)

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

Project Tasks:

1. Multi-stakeholder Landscape Design Process

   Led by Antares Group, contributions by AgSolver & FDC Enterprises

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

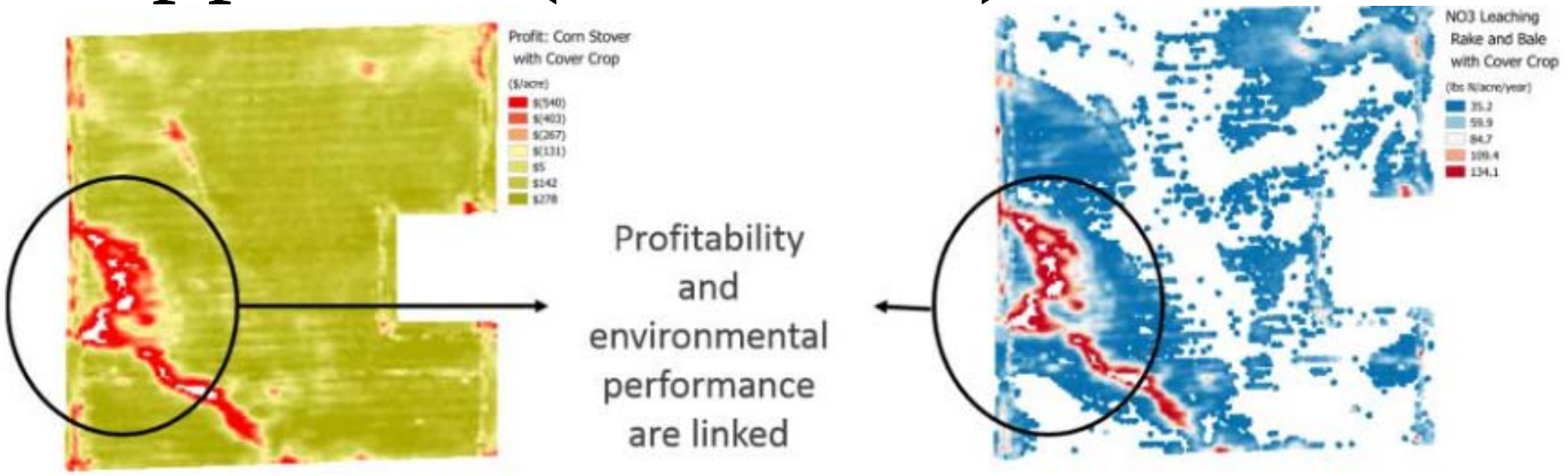
4. Analytical Approaches for Subfield Analyses

   Led by AgSolver, contributions by Penn State, INL, Purdue, ANL

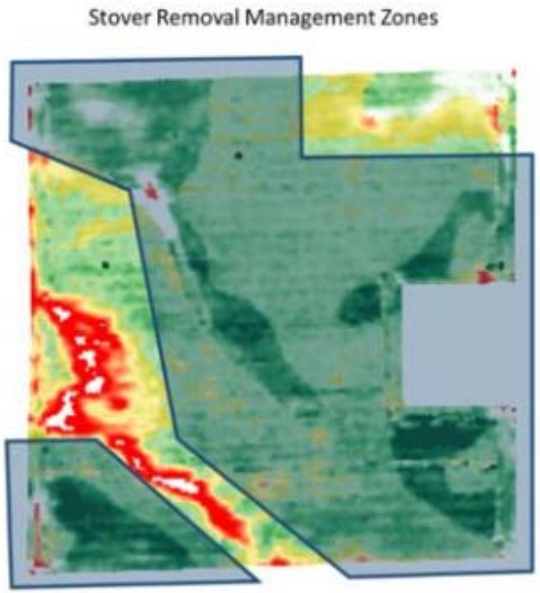
5. Targeted Feedstock and Environmental Assessment Data

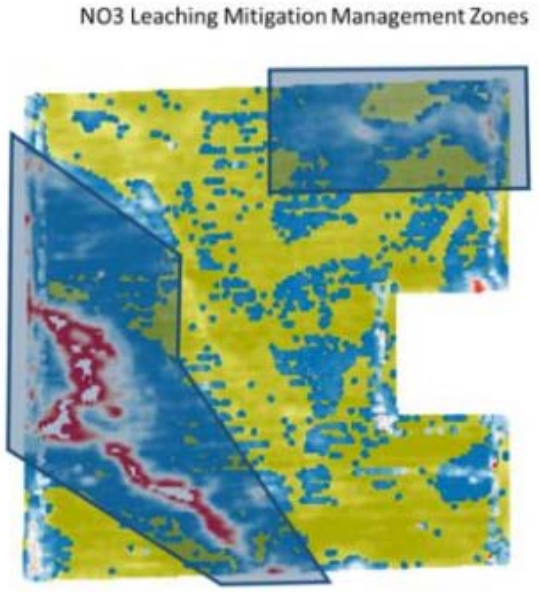
   Led by USDA-ARS with contributions by Antares & FDC Enterprises

Approach (Technical)



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





Assembling Key Pieces of the Puzzle

Advanced Harvest & Logistics, 2nd Pass

Regional Impact Modeling & Monitoring

Perennial Grass for Conservation & Biomass Supply

Implementation of Conservation Practices (Cover Crops, Buffer Strips, etc.)

Subfield Precision Business Planning

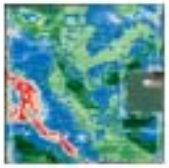
Advanced Harvest & Logistics, First Pass

Sustainable Residue Harvest

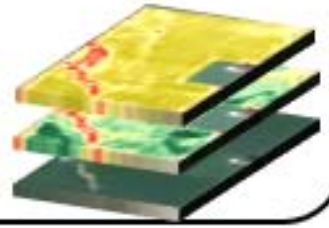
Multi-stakeholder Outreach

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)

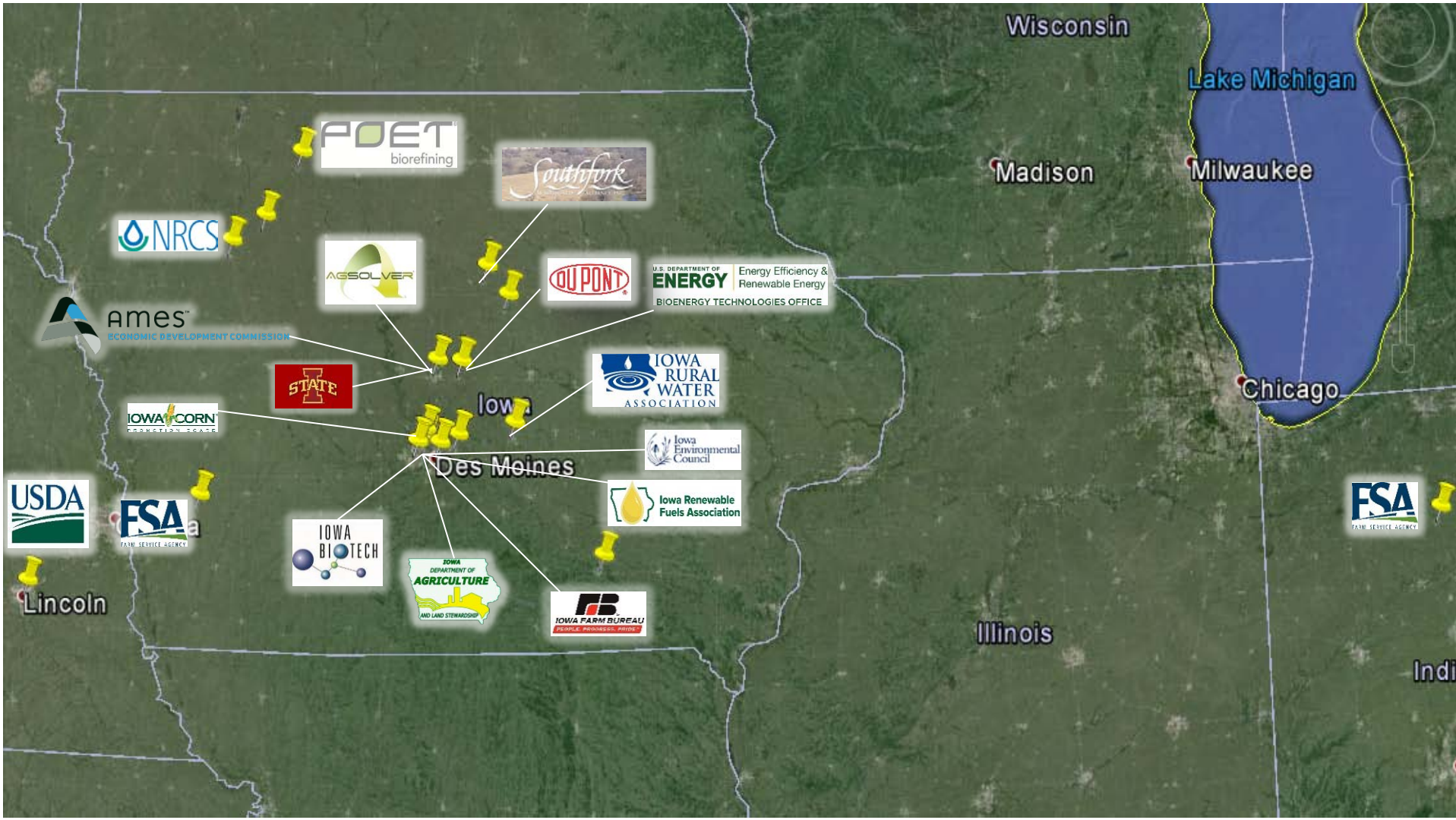
* Follow-Up Data Collection

Field Harvest Conducted

* Harvest Data Collection, Analysis, Reporting

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

Multi-Stakeholder Outreach



CP-38 Pheasant Recovery Participant Promotion

Antares Group and install partner FDC Enterprises, Inc. in cooperation with the local SWCD, FSA and NRCS are seeking landowners enrolled in the CP-38 Pheasant Recovery program to participate in a landscape design project funded by the US Department of Energy. An objective of the project is to assess the potential biomass yield that could be produced in the area and the environmental benefits of CRP establishment practices. Participants will receive numerous incentives described below.

Participant Incentives:

- **Full establishment of your CRP practice free of charge. The team will pay for the portion of your project not covered by FSA's cost share and practice incentive payments. All seed, chemical and establishment will be arranged for you.**
- **Establishment of your CRP practice by a company with over 270,000 acres of CRP establishment experience.**
- **Optional whole farm profitability assessment with Agsolver.**
- **Optional financial and technical assistance for additional projects such as buffer strips and saturated buffers.**
- **Optional payments for harvest of 1/3 the native mix, in nesting cover portion only, of CRP practice in years 4, 5 and 6. Harvest of winter cover is not authorized.**

Contract Terms:

- 5 year assessment of CRP establishment. The team will periodically take measurements related to soil erosion, water quality and wildlife benefits.
- Information gathered on your CRP planting will remain anonymous.
- All results will be shared with cooperator.
- Cooperator to abide by all rules of CRP program.

SIGN UP PERIOD:
DEC 15th - SEPT 30th

To learn more about the landscape design project and participation in the program contact us at:
712-253-6628
515-313-0080
tom@fdcenterprises.com

ANTARES Group Incorporated

FDC Enterprises, Inc.
www.fdcenterprises.com

FDC Enterprises, Inc., Antares Group Inc., IDALS and USDA are Equal Opportunity Employers

Environmental Indicators

Environment	Indicator	Units
Soil quality	1. Total organic carbon (TOC)	Mg/ha
	2. Total nitrogen (N)	Mg/ha
	3. Extractable phosphorus (P)	Mg/ha
	4. Bulk density	g/cm^3
Water quality and quantity	5. Nitrate concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	6. Total phosphorus (P) concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	7. Suspended sediment concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	8. Herbicide concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	9. storm flow	L/s
	10. Minimum base flow	L/s
	11. Consumptive water use (incorporates base flow)	feedstock production: m^3/ha/day; biorefinery: m^3/day

Environment	Indicator	Units
Greenhouse gases	12. CO_2 equivalent emissions (CO_2 and N_2O)	kgC_{eq}/GJ
Biodiversity	13. Presence of taxa of special concern	Presence
	14. Habitat area of taxa of special concern	ha
Air quality	15. Tropospheric ozone	ppb
	16. Carbon monoxide	ppm
	17. Total particulate matter less than 2.5µm diameter ($PM_{2.5}$)	µg/m^3
	18. Total particulate matter less than 10µm diameter (PM_{10})	µg/m^3
Productivity	19. Aboveground net primary productivity (ANPP) / Yield	gC/m^2/year

Credit: Virginia Dale & Keith Kline, Oak Ridge National Lab

Feedstock Logistics

- The Straeter Header is being upgraded for variable rate harvesting









ANTARES Group Incorporated

FDC Enterprises Grasslands Services

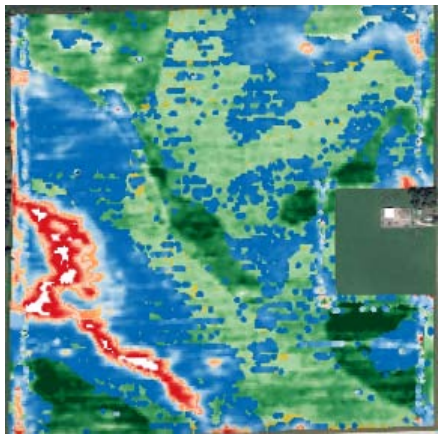
OAK RIDGE National Laboratory

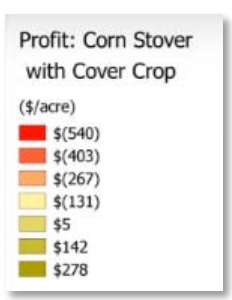
STATE

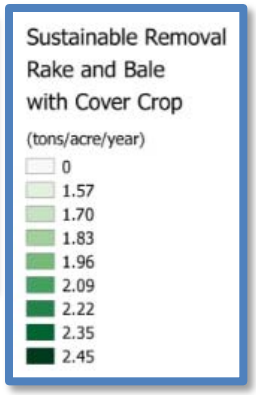
INL Idaho National Laboratory

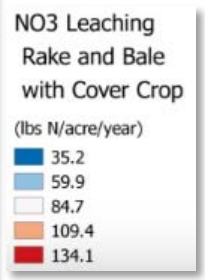
PacificAg

Straeter Header: Sustainable, Variable-Rate Harvest







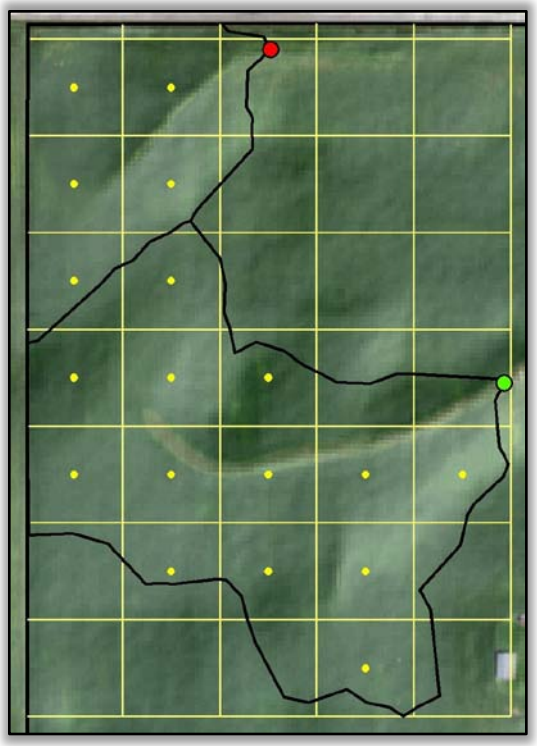


Credit: AgSolver

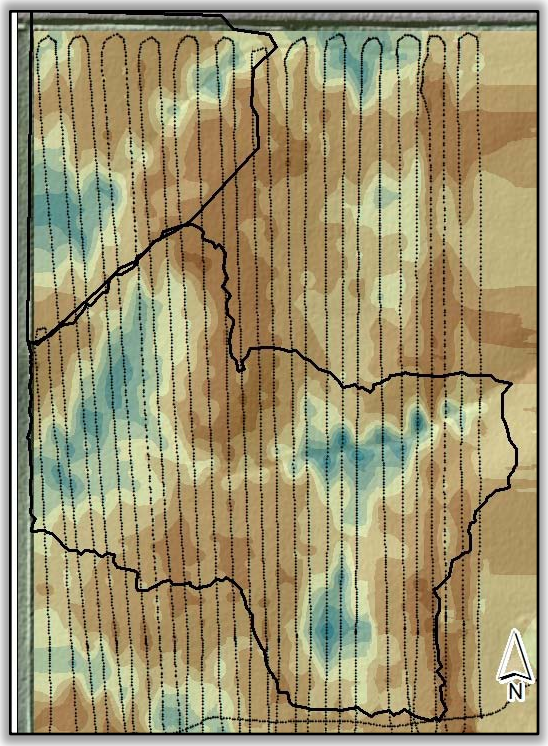
Advanced Data Analytics + Advances in Machine & Controls Technology and Feedstock Logistics = Improved: Sustainability, Biomass Supply Potential, Economics

USDA-ARS: Monitoring Site Selection

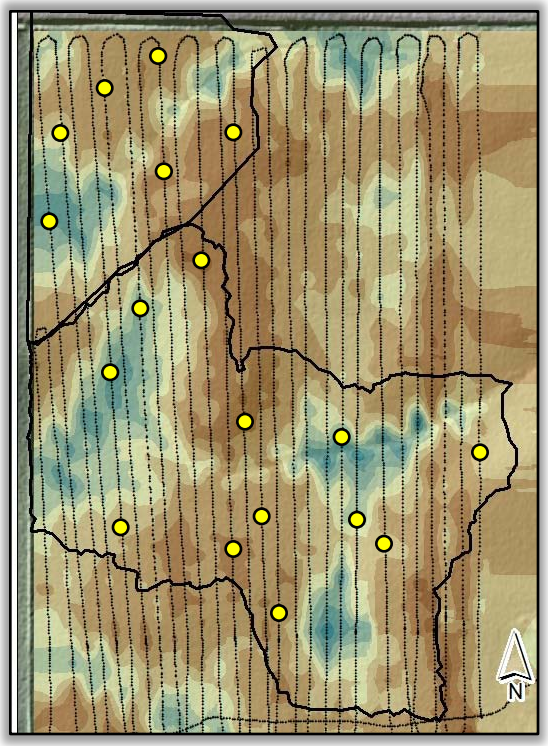
- *Site selection based on available acres enrolled in BLDP*
- *Electrical conductivity mapping (EM) used to map soil properties*
- *Soil sampling directed by statistical models to capture site variability*
- *Sampling to begin Spring 2017/Fall 2017*



Traditional grid-sampling (1-acre grid)



EM survey identifying landscape zone soils



Directed soil sampling

USDA-ARS: Soil Health Monitoring

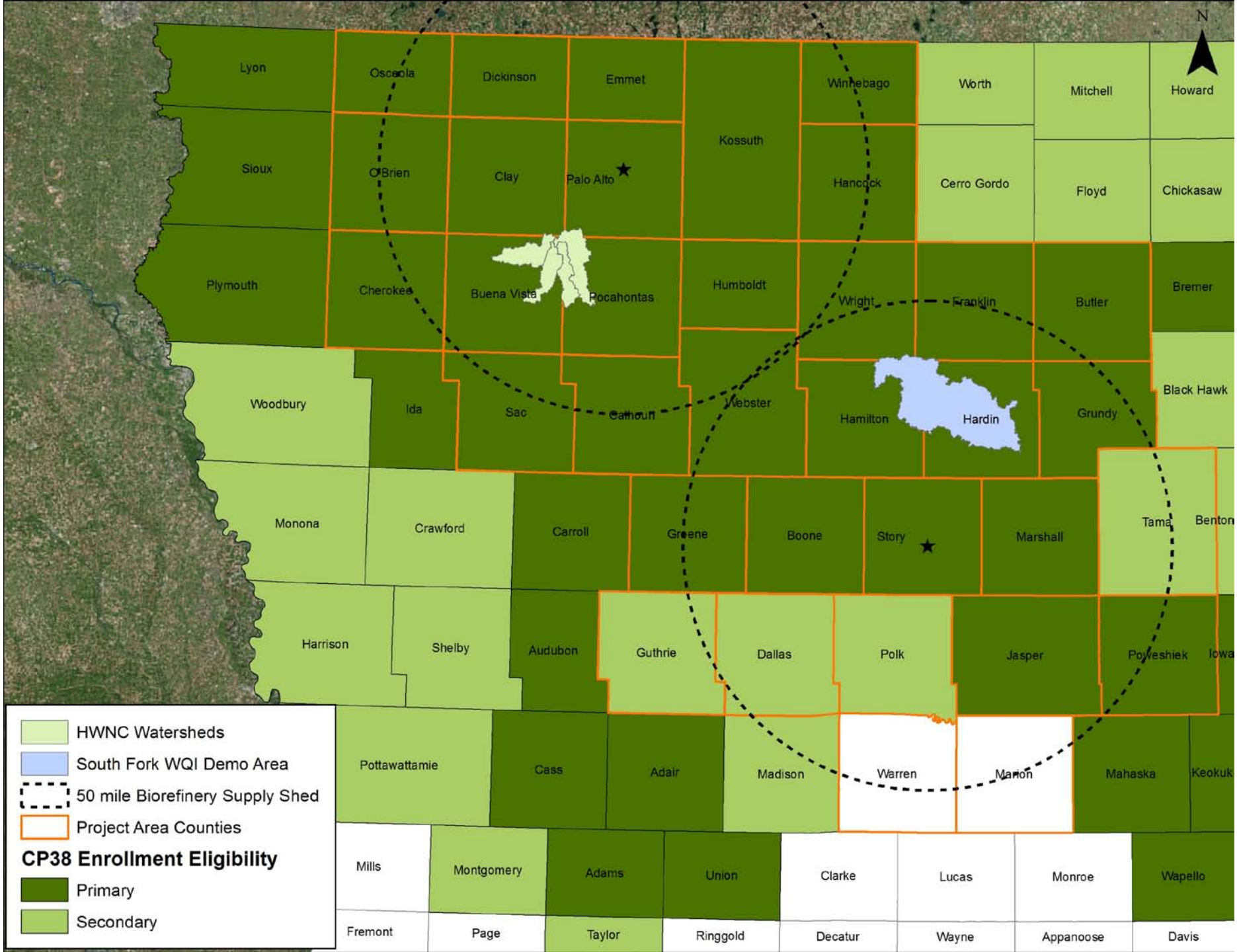
- *GOAL: Evaluate impacts of converting from row-crop to perennial grass and subsequent biomass removal on soil health (23 metrics)*

Property	Soil Health Metrics	ARS Lead Scientist	Location
PHYSICAL	Bulk density	D. Karlen	Ames, IA
	Particle size analysis Dry aggregate size distribution	J. Johnson	Morris, MN
	Macro-/micro-aggregate stability	M. Mikha	Akron, CO
CHEMICAL	Soil pH Electrical conductivity Extractable P, K, Ca, Mg, Fe, Mn, Zn, Cu, B	D. Karlen	Ames, IA
BIOLOGICAL	Permanganate oxidizable C Autoclaveable citric acid-extractable N β–glucosidase activity Short-term mineralizable C	M. Lehman	Brookings, SD
	Soil organic carbon, total nitrogen	D. Karlen	Ames, IA
	Particulate organic matter	M. Mikha	Akron, CO

- *Input soil results into the Soil Management Assessment Framework (SMAF) to quantify management effects on soil health (Lead: V. Jin, Lincoln, NE)*

Technical Accomplishments

- Have signed up over 3,000 acres for project participation with the project
  - Not including stover harvest acres, switchgrass acres in Virginia (600 acres)
- Initial watershed-level opportunity mapping
- 20 producers taken through AgSolver analysis
- Field research planning, initial testing
- Modelling group and co-ordination underway
- Published paper on sustainability indicators
- Near completion of web-based sustainability tool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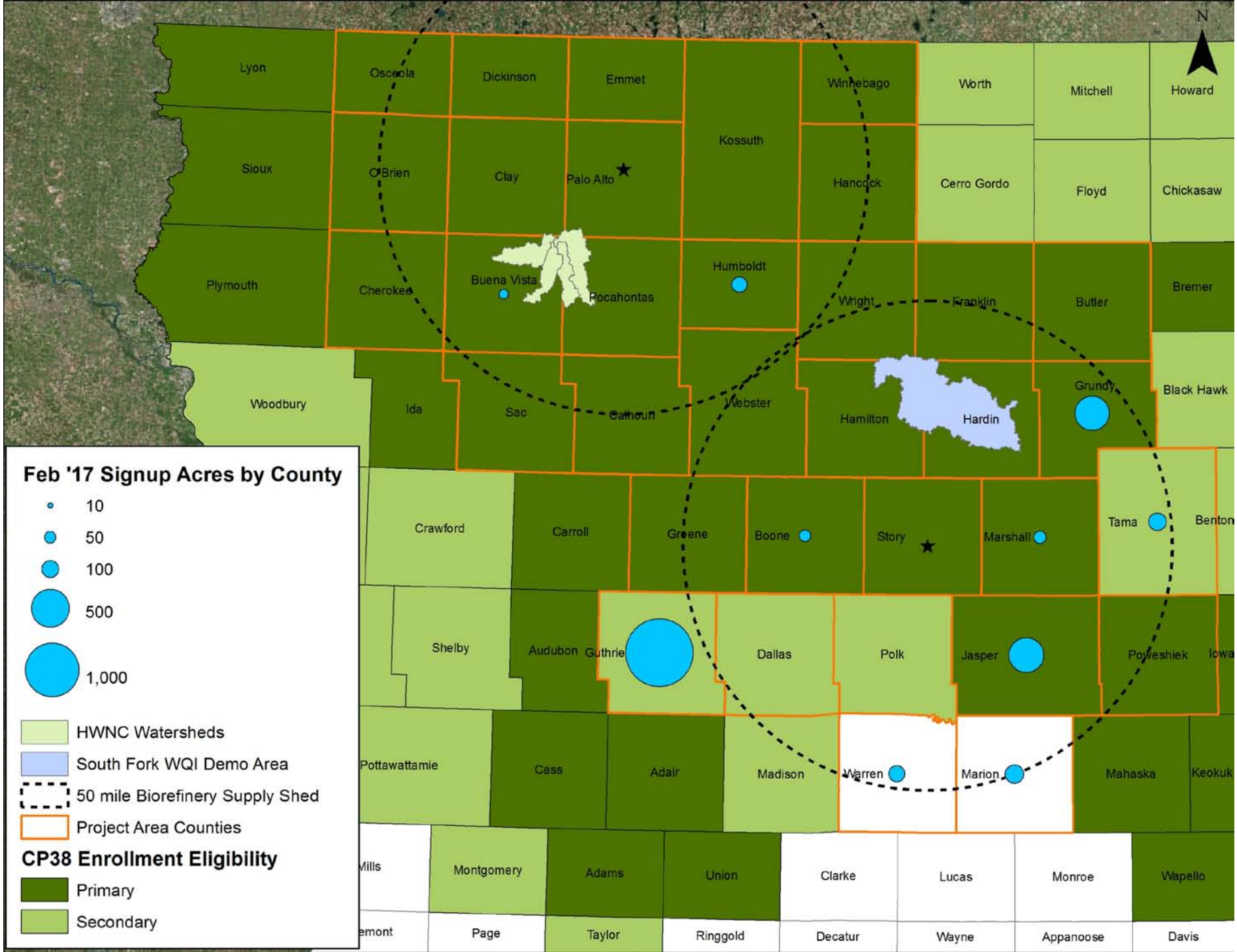
Osceola
Dickinson
Emmet
Winnebago
Worth
Mitchell
Howard
Sioux
O'Brien
Clay
Palo Alto
Kossuth
Hancock
Cerro Gordo
Floyd
Chickasaw
Plymouth
Cherokee
Buena Vista
Pocahontas
Humboldt
Wright
Franklin
Butler
Bremer
Woodbury
Ida
Sac
Calhoun
Webster
Hamilton
Hardin
Grundy
Black Hawk
Monona
Crawford
Carroll
Greene
Boone
Story
Marshall
Tama
Benton
Harrison
Shelby
Audubon
Guthrie
Dallas
Polk
Jasper
Poweshiek
Iowa
Pottawattamie
Cass
Adair
Madison
Warren
Marion
Mahaska
Keokuk
Mills
Montgomery
Adams
Union
Clarke
Lucas
Monroe
Wapello
Fremont
Page
Taylor
Ringgold
Decatur
Wayne
Appanoose
Davis
HWNC Watersheds
South Fork WQI Demo Area
50 mile Biorefinery Supply Shed
Project Area Counties
CP38 Enrollment Eligibility
Primary
Secondary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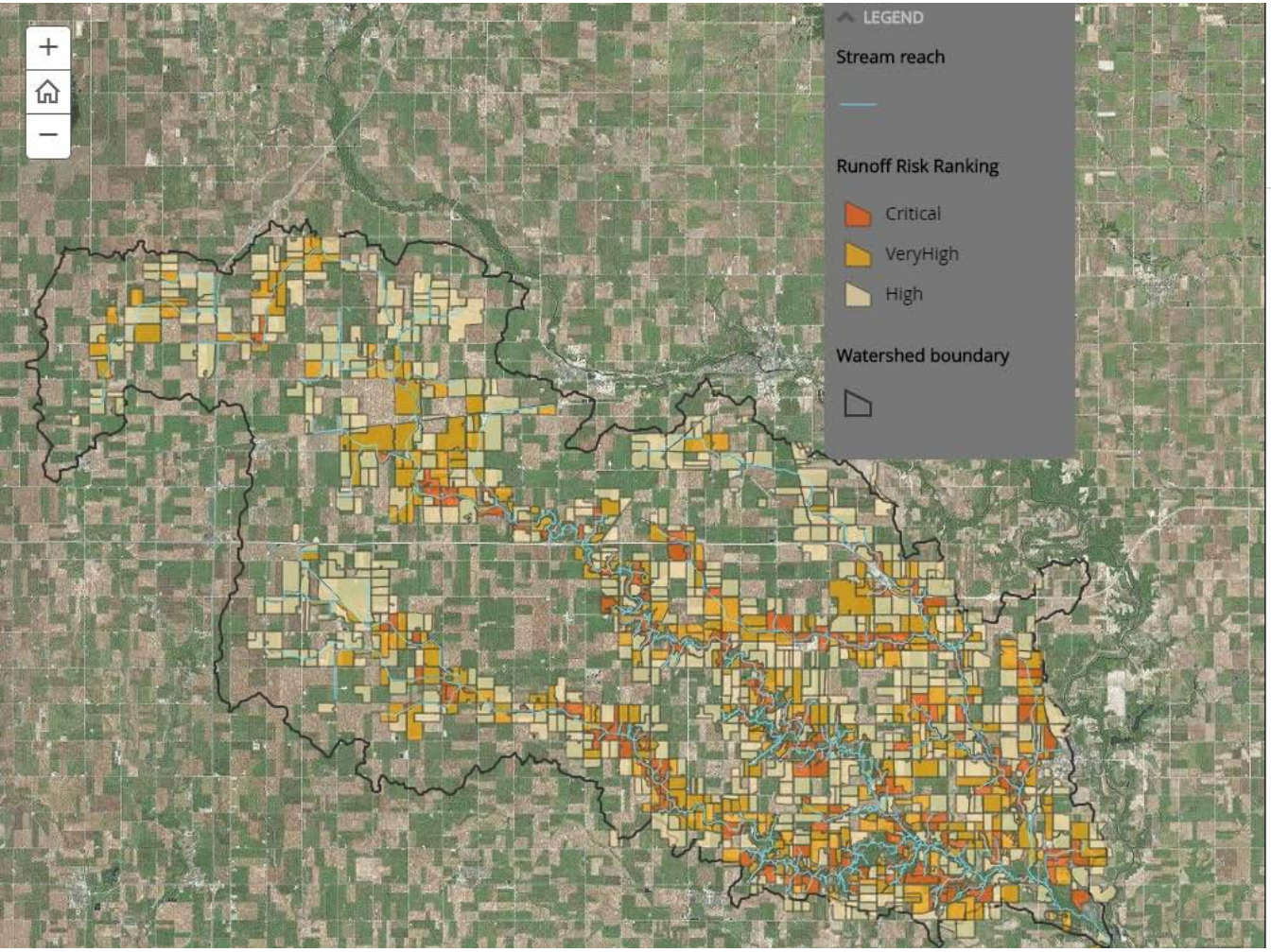
Plymouth
Cherokee
Buena Vista
Pocahontas
Humboldt
Wright
Franklin
Butler
Bremer
Woodbury
Ida
Sac
Calhoun
Webster
Hamilton
Hardin
Grundy
Black Hawk
Crawford
Carroll
Greene
Boone
Story
Marshall
Tama
Benton
Shelby
Audubon
Guthrie
Dallas
Polk
Jasper
Poweshiek
Iowa
Pottawattamie
Cass
Adair
Madison
Warren
Marion
Mahaska
Keokuk
Mills
Montgomery
Adams
Union
Clarke
Lucas
Monroe
Wapello
Page
Taylor
Ringgold
Decatur
Wayne
Appanoose
Davis
Feb '17 Signup Acres by County
10
50
100
500
1,000
HWNC Watersheds
South Fork WQI Demo Area
50 mile Biorefinery Supply Shed
Project Area Counties
CP38 Enrollment Eligibility
Primary
Secondary

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

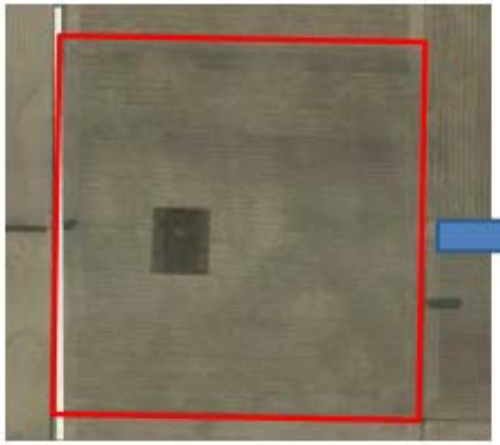
The inset map below shows a suitable area for drainage water management between the South Fork and Tipton Creek channels. This is a relatively flat area within the watershed, making it ideal for drainage management

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.

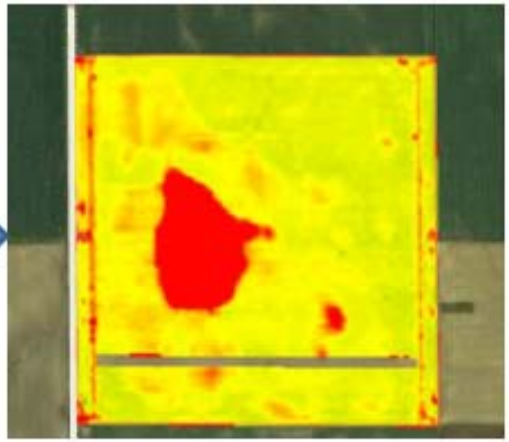
Initial Target Field Examples

AGS-002 Field Information

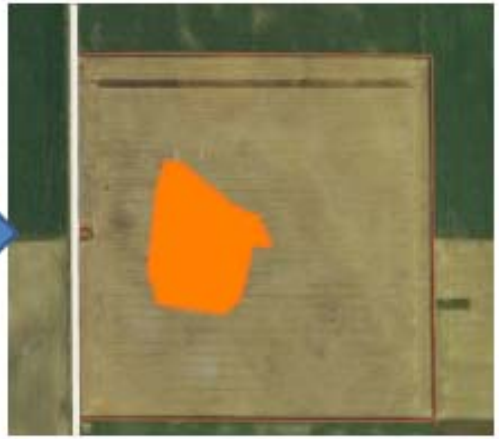
Field Boundary



Profit Zone Map



Potential Conservation Area

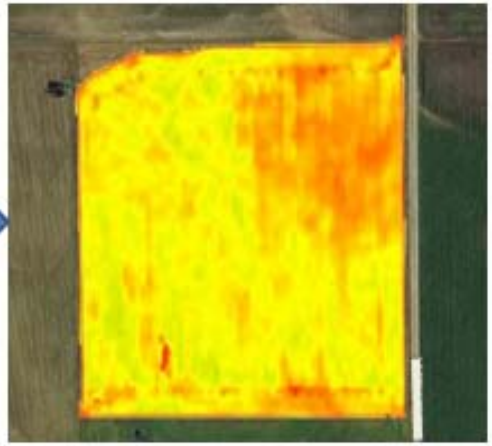


Total Field Size: 154.32 acres; Conservation Area: 15.3 acres; Conservation Practice: CSP

AGS-007 Field Information

Field Boundary

Profit Zone Map



Potential Conservation Area

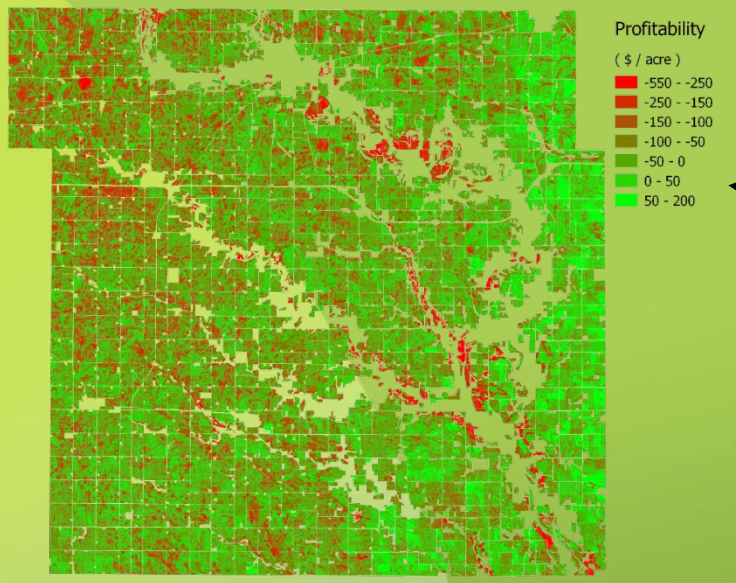
Total Field Size: 65.26 acres; Conservation Area: 16.07 acres; Conservation Practice: CRP

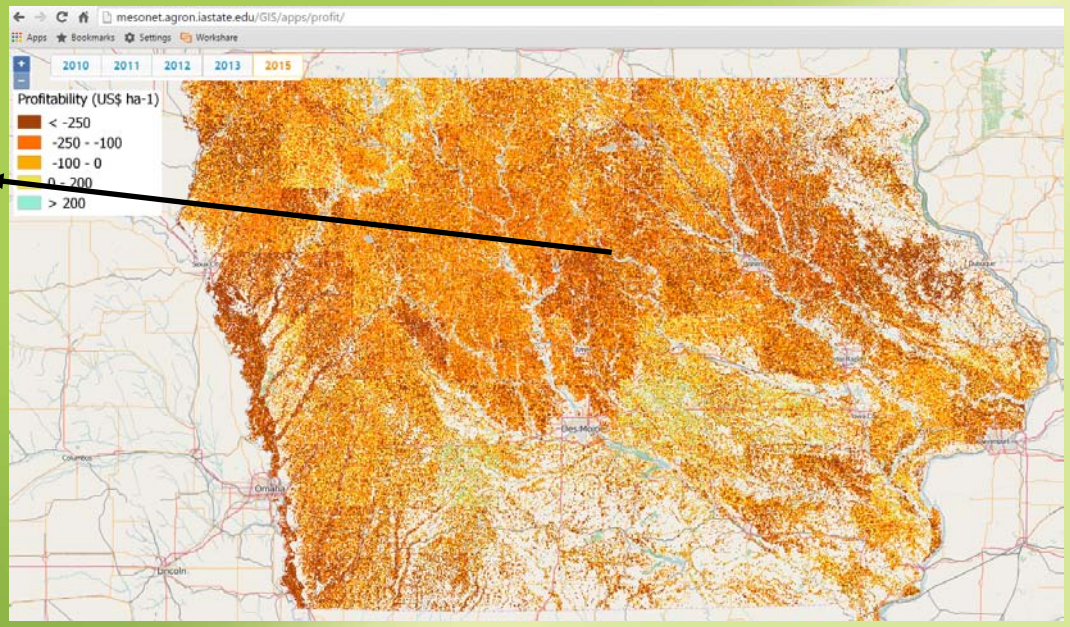
Virginia Switchgrass Harvest

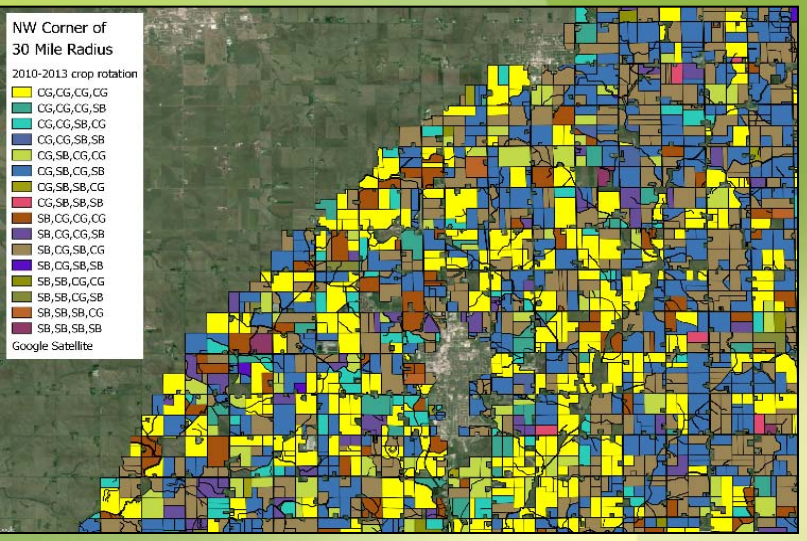
Relevance

- Project is focused on the most important region (today) for cellulosic biofuel production from herbaceous biomass
- We NEED better strategies for building energy crop supplies sustainably and profitably
- Examples from 3 key perspectives:
  - State-level
  - Biorefiner
  - Landowner

Identifying the Opportunities



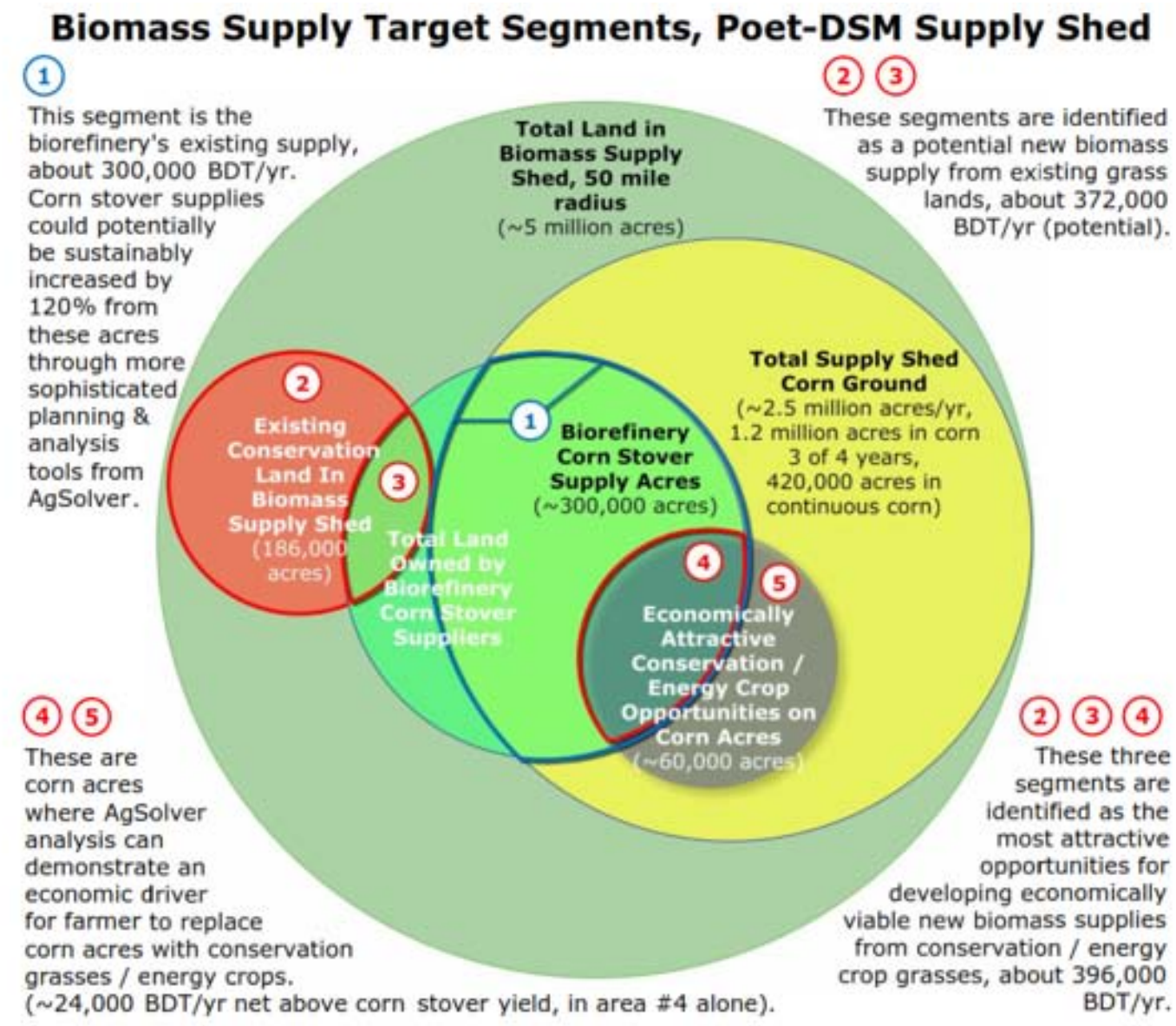




- Between 2-3 million acres annually at an expected loss
- Over $1B annually in misallocated working capital

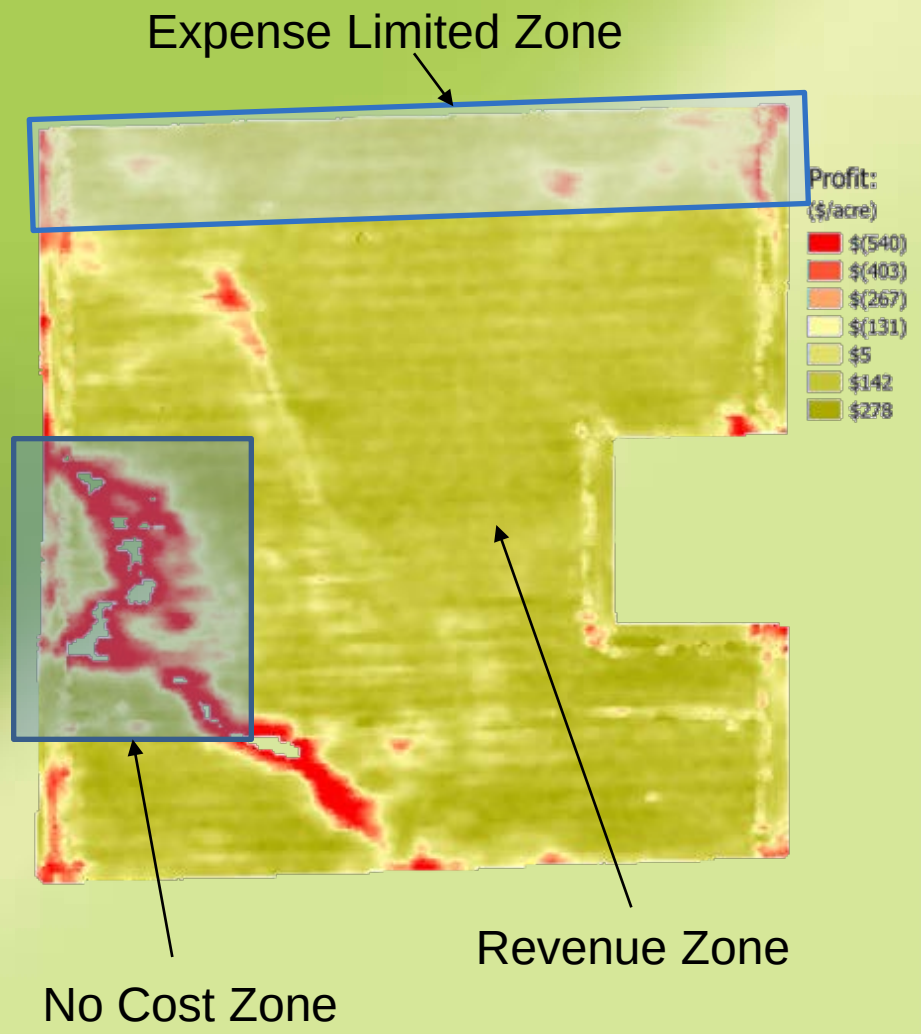
Example Impacts for a Biorefinery

- Could our approach make a difference?
- Yes!
  - 120% increase in corn stover supply (sustainable)
  - 133% of biorefinery needs from grasses that provide conservation benefits



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)



Seeking Combined Benefits

- We are seeking to help enable:
  - Increased conservation benefits, AND
  - Increased biomass supplies, AND
  - Increased farm profitability, AND
  - Increased rural employment opportunities, AND
  - Increased energy security through improved domestic potential to supply more energy renewably from biomass
- Changing the culture of agriculture is needed

  "The definition of insanity is doing something over and over again and expecting a different result."

5 – Future Work

- Research field selection and data collection
  - 24 fields, multi-year
  - Perennial grass (feedstock) establishment in targeted areas, 3,000 acres enrolled to date
  - 1,700 acres (minimum) by October 2018
  - Base model development to measure environmental and socioeconomic sustainability indicators
- Ongoing multi-stakeholder outreach activities
  - Environmental and economic analysis of target fields
- Model Development and Optimization Efforts
- Annual harvest operations & monitoring

Summary

1. Overview

To further the bioenergy industry, a sustainable feedstock supply should be developed using proven Landscape Design changes that are environmentally beneficial, profitable to growers, and increase supplies to biomass end users.

2. Approach

The BLDP team is working to accomplish these objectives through identifying fields in our targeted region where profit-driven Landscape Design changes create measurable environmental & social benefits. Measured data will be used to optimize and validate research models that will be used to understand benefits to the region (watershed-level) as a whole.

3. Technical Accomplishments/Progress/Results

To date, the project team has secured ~3,000 acres of land for grass establishment under CP-38, using a FSA-approved bioenergy seed mix. USDA-ARS staff have developed plans to collect soil data from specific fields. Over 600 acres of switchgrass were harvested, with complete cost & performance data collected. The BMAS Sustainability Tool Interface is under development to implement a field-tested sustainability standard.

4. Relevance

Profit-driven (for the grower) Landscape Design changes, when implemented properly, will lead to a sustainable biomass feedstock supply. The data collected from these changes and the lessons learned will enable future successes in other bioenergy systems around the nation.

5. Future work

Ongoing multi-stakeholder outreach; field selection and data collection; Landscape Design implementation (selective perennial grass establishment); Biomass Sustainability Tool testing; modeling development & optimization; preparation for Stage Gate Meeting (April 2018)

Back-up Slide

Projected Impacts by 2030

	Business as Usual: Projected CRP	**Business as Usual with New Harvestable Acres:** All New Acres Harvestable	**Proposed Scenario:** 10% of All New Conservation Acres are Enrolled in the Program
Total Acreage	24,000,000	32,000,000	24,000,000
CRP *Bioenergy*	*24,000,000* *0*	*24,000,000 (75%)* *8,000,000 (25%)*	*21,885,000 (91%)* *2,114,000 (9%)*
Harvest Yield (tons/year)	0	48,000,000	12,553,000
Jobs Created (Annual FTE) [3]	0	17,355	4,539
Economic Value Biomass Market Value ($80/ton) Avoided Petroleum Value ($250/ton)	 $0 $0	 $3,840,000,000 $12,000,000,000	 $1,004,000,000 $3,138,000,000
Nutrient Runoff Reduction [1] Nitrogen Phosphorus	 85% 75%	 72% 34%	 83% 69%
Net Decrease in Erosion vs. Row Crop [2]	98.6%	78.1%	95.7%