U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

4.2.1.20

Integrated Landscape Management

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Sustainability Technology Area

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PROJECT GOAL

- OBJECTIVE
  - Develop model based innovative landscape design methods that estimate increased biomass availability, improve soil, water, and air quality, and reduce grower losses through subfield management decisions. Validation is through partnerships with USDS-ARS, Regional Partnerships and Universities.

- DOE BETO LINK
  - By 2018, using available field data, validate case studies of biofuel production from agricultural residues and energy crop systems
    - St-G: Representation of Land Use and Innovative Landscape Design
  - Inform 2017 feedstock platform goal $80/dry ton delivered feedstock
    - Ft-A: Feedstock Availability & Cost

- OUTCOME & RELEVANCE
  - Innovative landscape management methods & fundamental data layers
  - Deployable tools for landscape managers and policy makers
  - Improve sustainable biomass supply for bioenergy
  - Reduce feedstock cost resulting from increased availability

QUAD CHART

- TIMELINE
  - Start Date: FY14
  - End Date: FY17
  - Percent Complete: 30%

- BUDGET

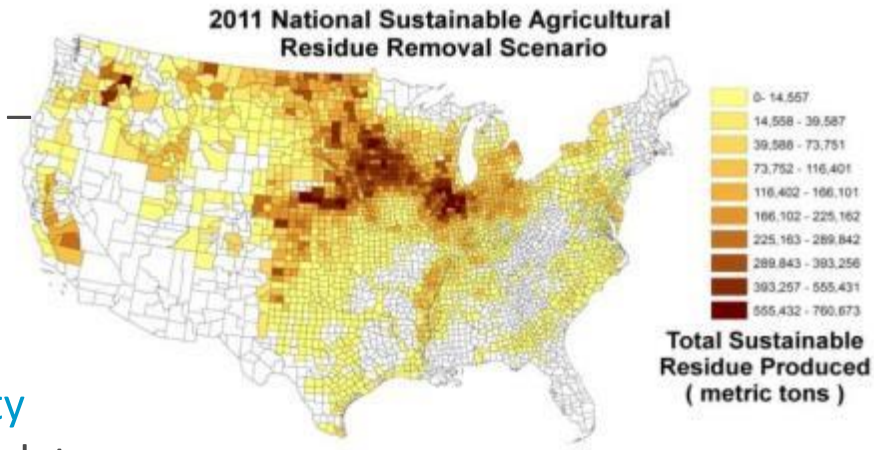
	Total Costs FY 14	FY 15 Costs	FY 16 Costs	Total Planned Funding (FY 17-Project End Date)
DOE Funded	450k	450k	450k	1.8M
Project Cost Share*				

*No cost share on this project

- BARRIERS
  - St-C: Sustainability Data across the Supply Chain
  - St-G: Land-Use and Innovative Landscape Design
  - Ft-A: Feedstock Availability and Cost

- PARTNERS
  - Lab Collaborators
    - ANL 4.2.2.1 (Wu)
    - ORNL 1.1.1.1 (Langholtz)
    - ORNL 4.1.1.40 (Jager)
  - Industry
    - AgSolver Inc.
  - Univ. & Agency
    - Iowa State University
    - USDA ARS & NRCS
    - Purdue University

PROJECT OVERVIEW

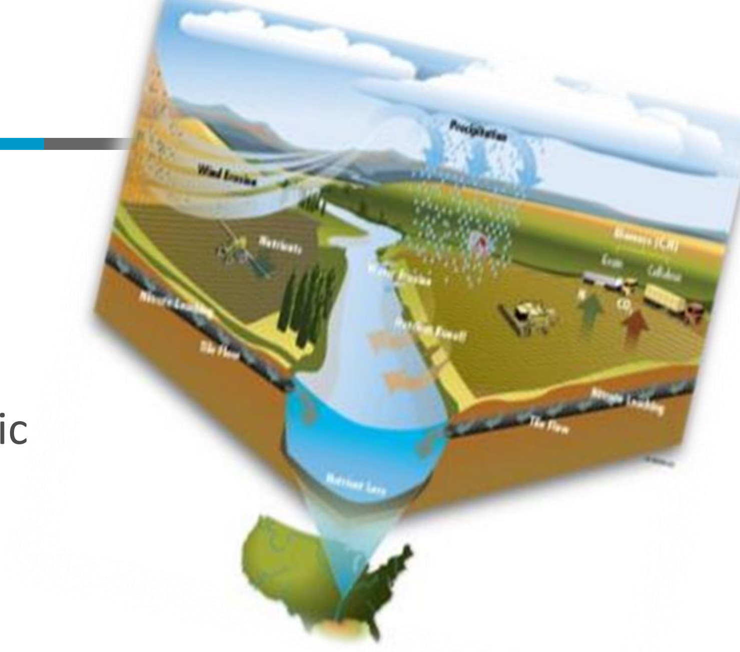


- HISTORY
  - In FY14 project emerged from WBS 1.1.1.2 – Sustainable Feedstock Production-Logistics Interface
  - Development of LEAF (Landscape Environmental Assessment Framework) For assessing sustainable residue availability
  - Resource assessment for the Billion Ton Update

- CONTEXT
  - Large scale assumptions and coarse resolution analyses broaden the gap between leading knowledge and actionable information
  - Mono-feedstock, residue based systems are vulnerable to limitations and risks:
    - On- and off-site environmental impacts and constraints
    - Uncertain growing conditions; grower economics; social perception

- OBJECTIVES
  - Diversify and increase feedstock availability through energy crop integration
  - Increase overall biomass production, reduce grower losses, and improve environmental sustainability of biofuels.

TECHNICAL APPROACH



- REPLICABLE FRAMEWORK
  - Analysis framework utilizes well-vetted USDA and University models
  - Results are repeatable and applicable to specific locations and situations
- BOTTOM-UP APPROACH
  - Founded on subfield level decision making
    - Fundamentally alters the objective function of landscape design
  - Generates impactful and *actionable* information for growers & policy makers
  - Results are rolled up and aggregated to demonstrate large scale impact
- SUCCESS FACTORS
  - Products must be deployable, accessible, and implemented by stakeholders
  - Analyses must be replicable and actionable
  - Advance understanding and design of integrated bioenergy landscapes
- CHALLENGES
  - Retain realism while working at a fine scale across diverse regions
  - Capture diversity in management practices and applicability

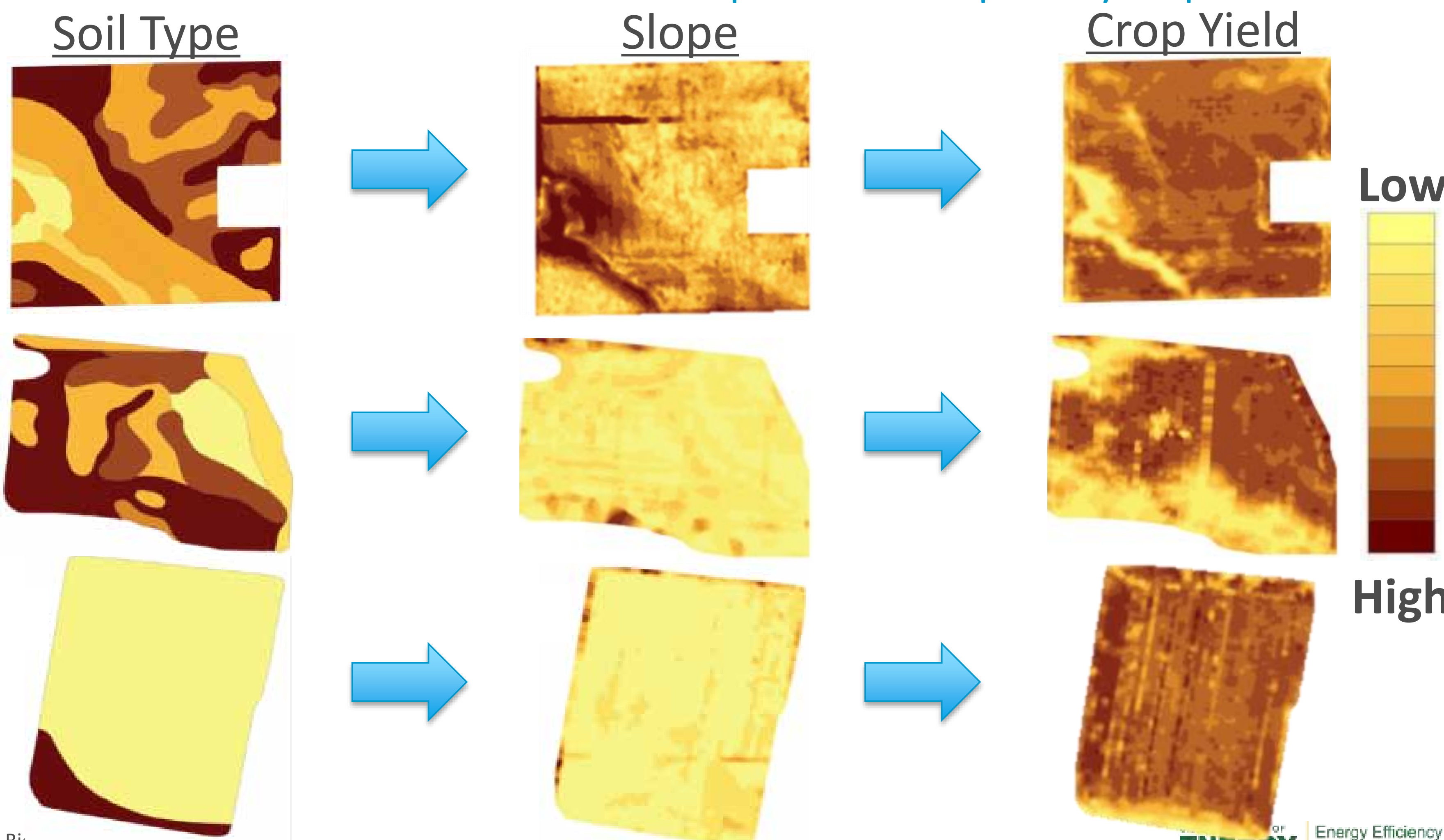
MANAGEMENT APPROACH

- **SUCCESS FACTORS**
  - Ability to tie biomass availability & sustainability to feedstock logistics
    - Quantitative and demonstrative analysis of feedstock procurement
  - Collaborative partnerships for higher impact and wider dissemination of results
    - Lab & academic partners to broaden specialties
    - Cross-agency and industrial partners in positions to interact with growers and biomass end users
      - USDA-ARS and NRCS; watershed working groups
  - Advance BETO's capability to produce repeatable analytical results compliant with MYPP metrics and targets.
  - Improve overall biomass availability while minimizing the impacts of reduced corn production

- **CHALLENGES**
  - Complexity and quantity of data integration across the supply chain
  - Project cohesion amongst varying disciplines (physical, biological, & social)
  - Ensure products reach key stakeholders (from growers to policy makers)

PROGRESS & RESULTS

- **Subfield Integration Approach**
  - Within-field variability presents unique challenges from field to field
  - Site conditions lead to variable production in primary crops

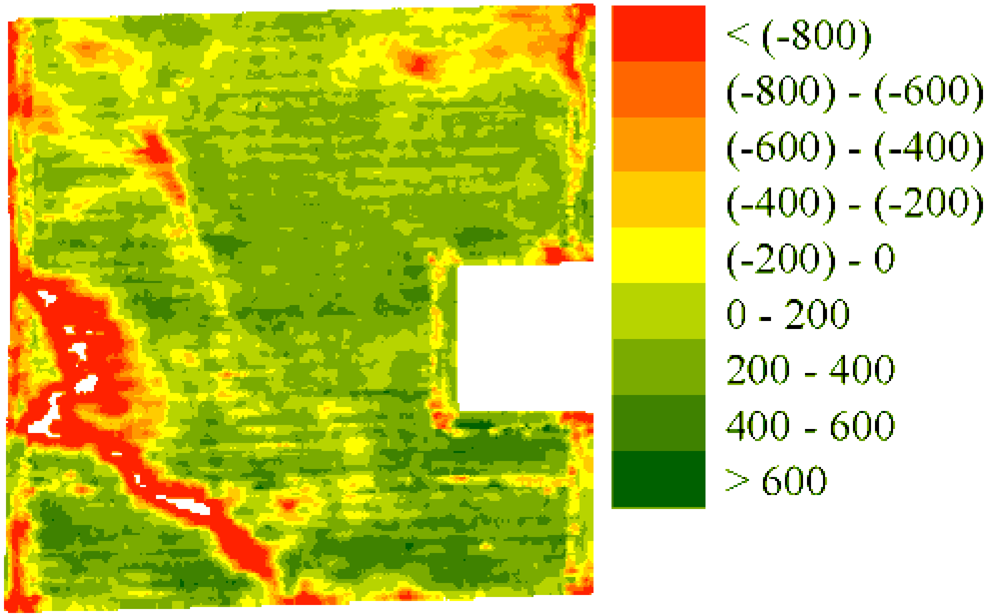


PROGRESS & RESULTS

- **Subfield Integration Approach**
  - Variable production leads to variable profit and return on investment
  - Small portions of fields consistently operate at a financial loss
  - Profitability then becomes difficult

	Annual Profit ($/ha/yr)
Mean	$47
Standard Deviation	$415

Annual Net Profit ($/ha)

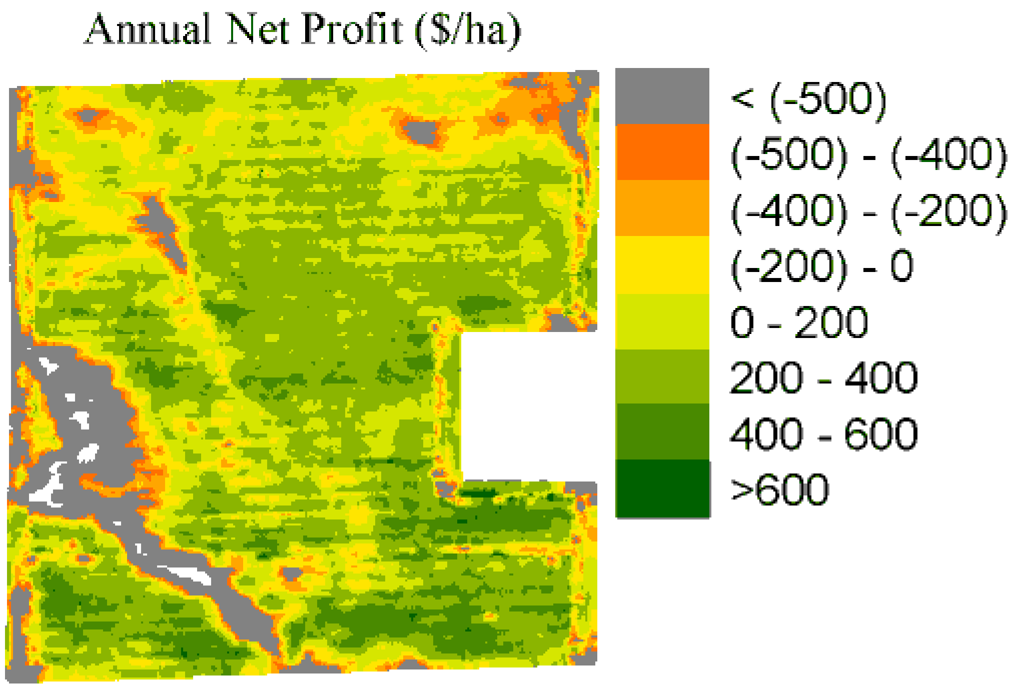


PROGRESS & RESULTS

- **Subfield Integration Approach**
  - Removing problematic areas from production reduces risk
  - Provides an opportunity for alternative land management
    - Energy crops – minimize losses while producing biomass

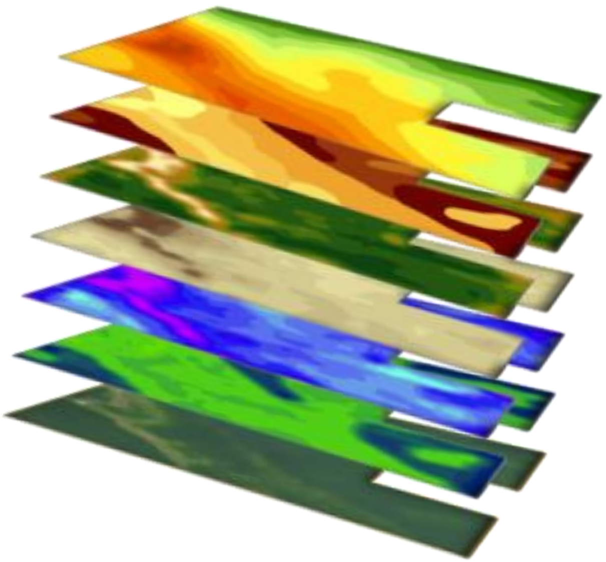
	Annual Profit ($/ha/yr)
Mean	$47
Standard Deviation	$415

-500 $/ha Area Removed	
Mean	$158
Standard Deviation	$215



PROGRESS & RESULTS

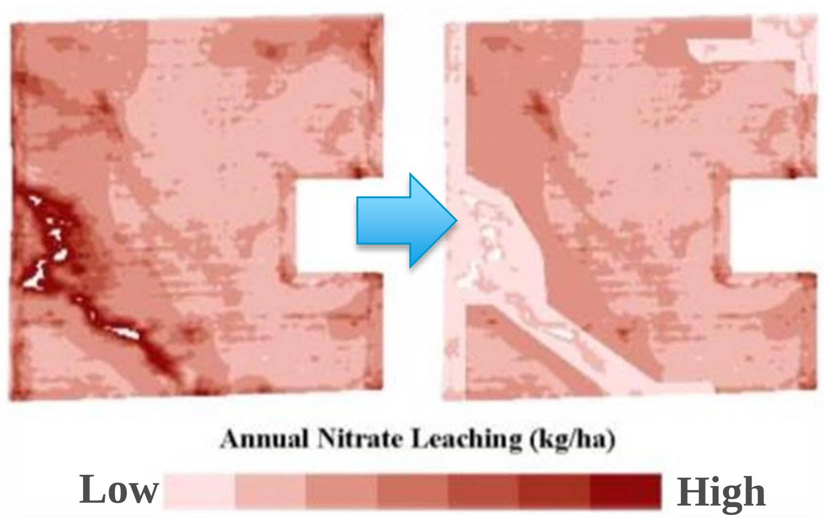
- **Designing Sustainable Bioenergy Landscapes**
- Energy crops are not only a conservation practice, but a financial loss mitigation strategy
- Use grower return to generate actionable information
- Multi-objective approach to targeting areas of the field based on:
  - ↑Subfield profit
  - ↑Grain productivity
  - ↓Soil erosion
  - ↓Nitrate Leaching
  - ↑Soil organic carbon gain

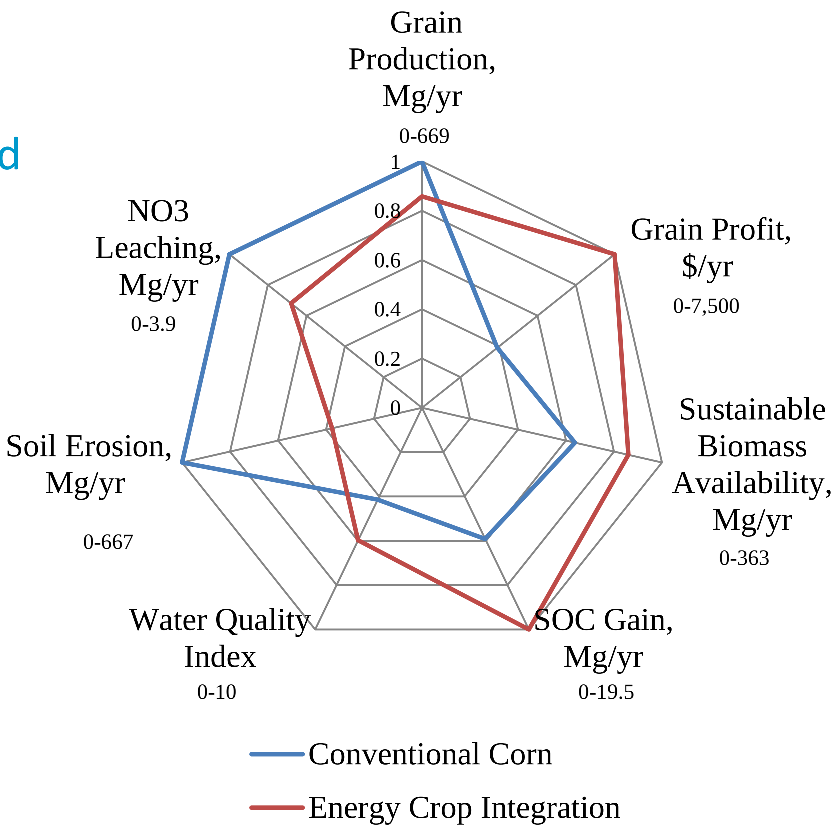


- Ultimately resulting in:
  1. Reduced Risk
  2. Increased biomass availability
  3. Improved sustainability
- **What's good for sustainability must be good for the *farmer***

PROGRESS & RESULTS

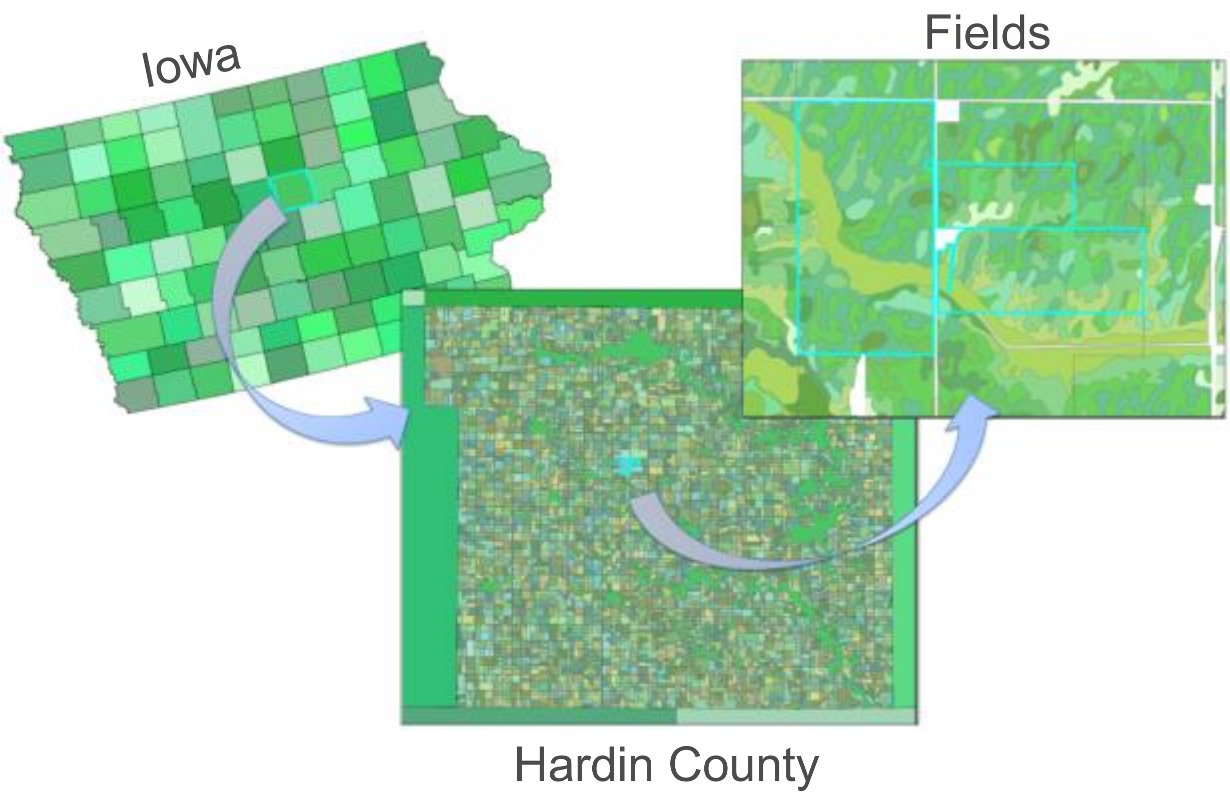
- **Impacts to Field Performance**
  - Reduced grain production, but improved financial return
  - 35% Increase in sustainable biomass yield
  - Improved soil health
    - 63% reduction in erosion
    - 69% increase in soil organic carbon gain rate
    - 32% reduction in nitrate leaching





PROGRESS & RESULTS

- **County Level Application**
- **Subfield management of larger spatial scales**
  - Field boundaries & subfield soils for Hardin County, Iowa
  - Over 4,000 fields producing corn within the county
    - Over 77,000 subfield areas



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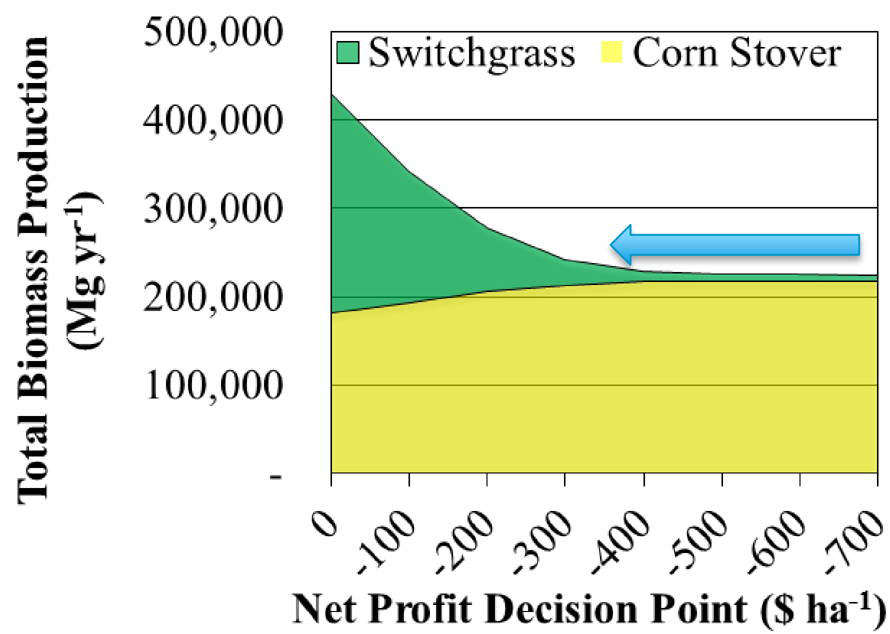
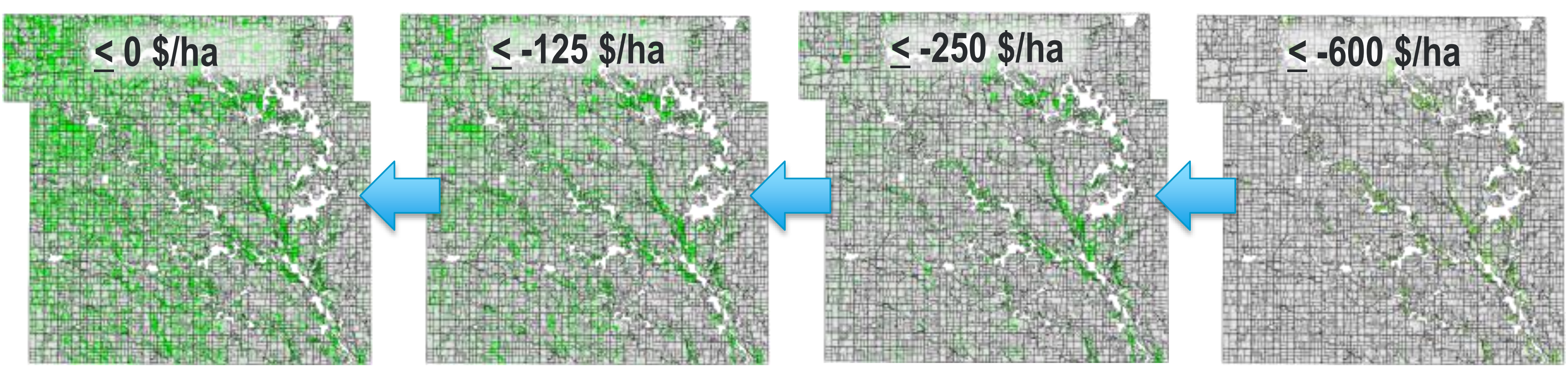
PROGRESS & RESULTS

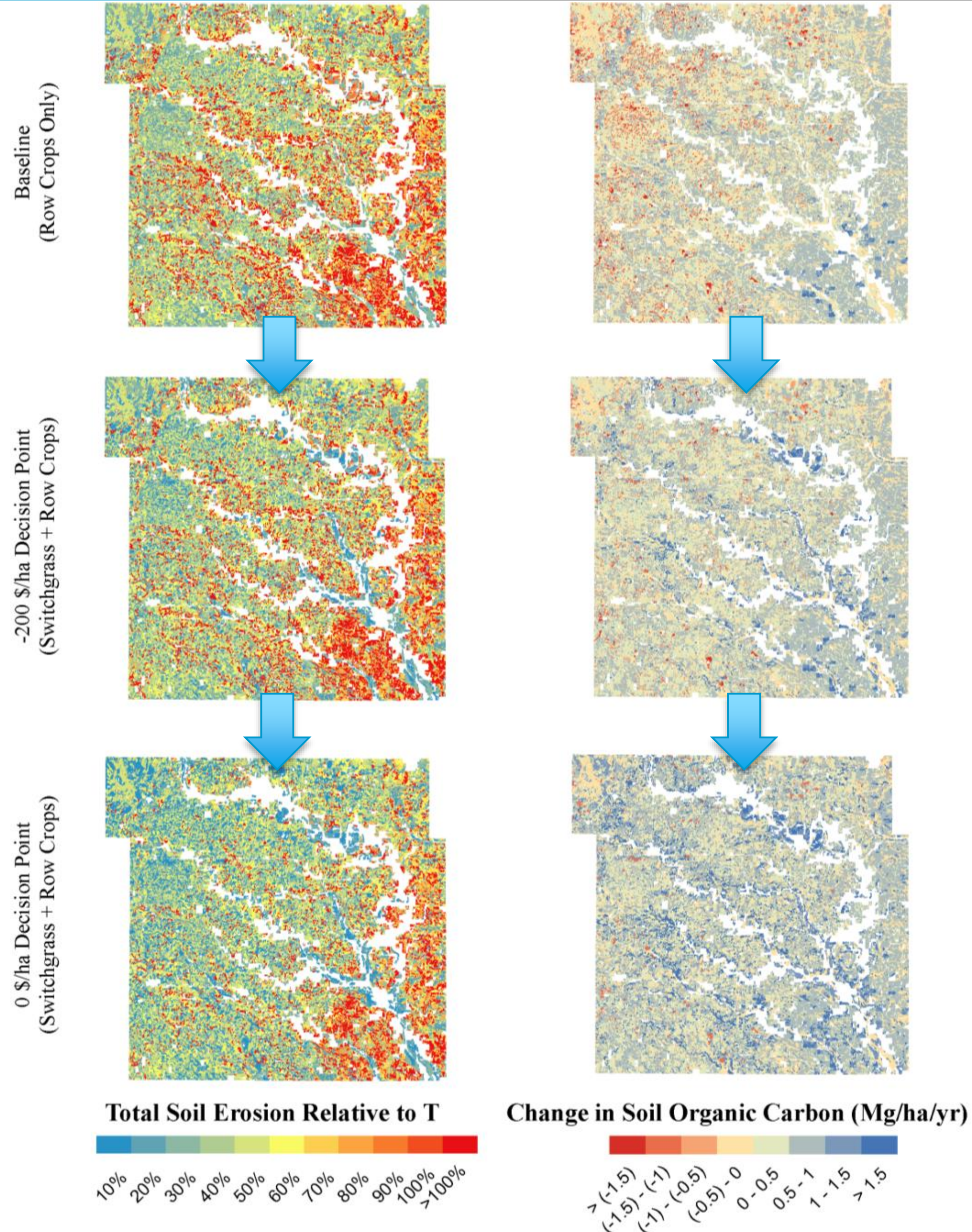
- **Opportunity dependent on energy crop's affordability**
  - **Gradient of land change**
    - 1% to 22% of land
    - 15% to 85% of fields
  - **Improved Biomass Production**
    - Up to 99% increase
  - **Diversity in feedstocks**





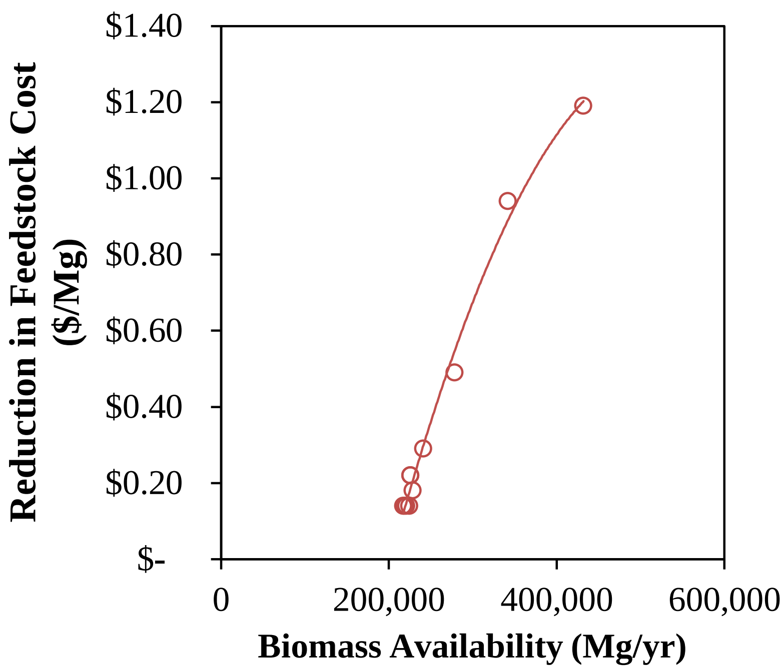
PROGRESS & RESULTS

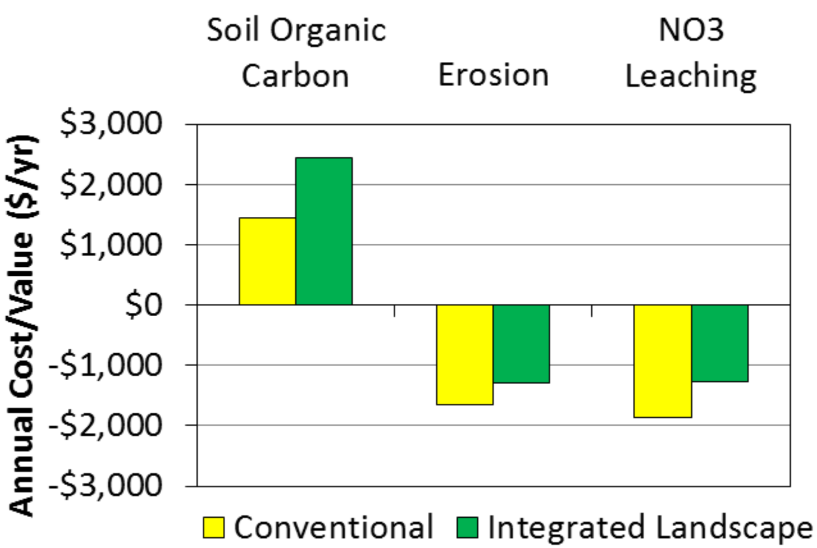
- **Opportunity dependent on energy crop's affordability**
  - **Improved Sustainability**
    - 24% Reduced erosion
    - 21% Reduced nutrient loss
    - 150% Improved soil organic carbon accumulation rates
    - 27% reduction in risk to surface water quality
  - **Reduced variability**



PROGRESS & RESULTS

- **Supply Chain Economics – Exploring Potential**
  - Increased biomass availability → **more cost-efficient logistics system**
  - Increased sustainability → **improved private and social value of soil health**





20 $/Mg Savings

RELEVANCE

- **BETO MYPP Contributions**
  - **2014 Goal:** Increased biomass production reduces the cost of access and increased diversity improves soil health.
  - **2016 Goal**: Demonstrate replicable application of landscape design methods that increase biomass availability, sustainability, and grower return.
- **Impact**
  - Advance the current state of technology on actionable landscape design methods
  - Robust and flexible datasets and deployable tools to meet dynamic needs
    - Most importantly, inform practical incorporation of energy crops at the subfield level paired with sustainable residue harvesting
  - Critical forward looking support to developing environmentally, socially, and economically sustainable practices for biofuel production.
- **Stakeholders**
  - Land managers – support for precision agronomics and reduced risk
  - Researchers – address high-level biomass availability concerns
  - Industry – inform biomass end users on sustainable biomass supply and strategy
  - Policy makers – clear communication of pathways to achieving sustainable energy and land stewardship for long term security

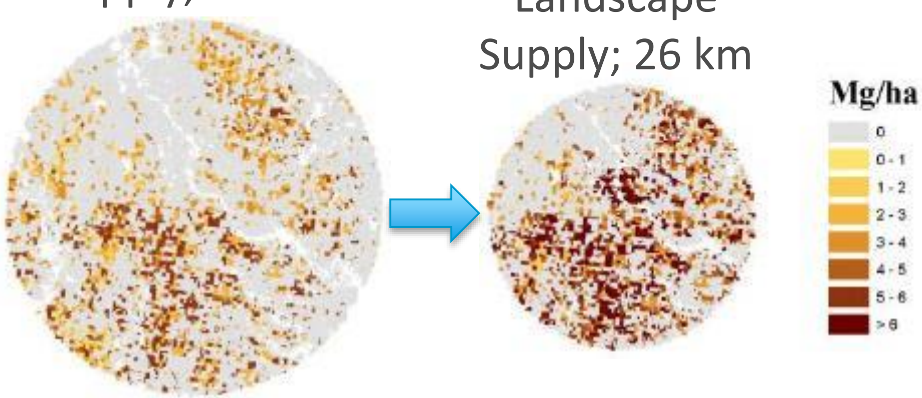
FUTURE WORK

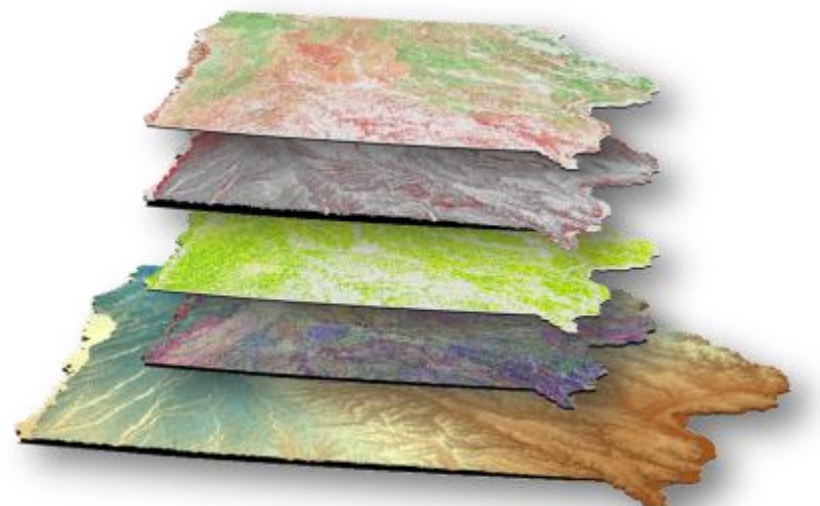
- **Billion Ton 2016 Support**
  - Impacts of sustainability and practicality constraints
  - Improvements to feedstock logistics
- **Milestone**
  - Case study examination - **Q3 FY15**

- **Deployable Data-Exploration Tools**
  - Dissemination of project data
  - Access for researchers and land managers
- **Milestones**
  - Data layers made available on BETO web services **Q3 FY15**
  - Application launch **Q4 FY16**

Conventional Stover-Only Supply; 37 km

Integrated Landscape Supply; 26 km





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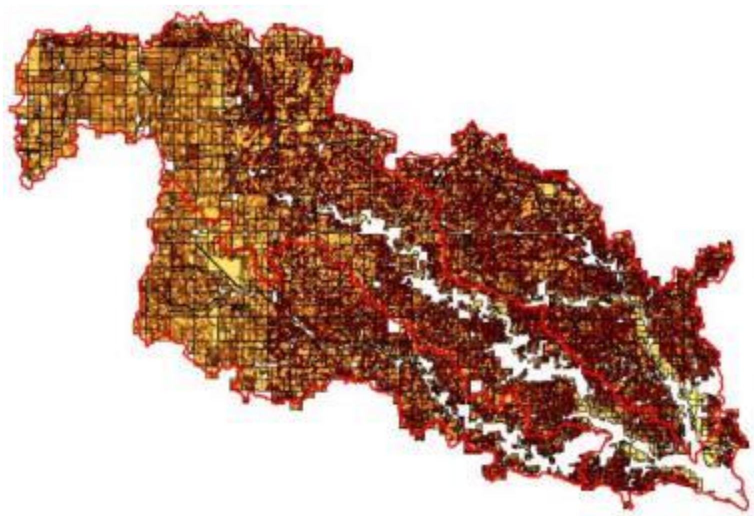
FUTURE WORK

- **Expansion of Analytical Methods Across the US**
  - Assess potential of energy crop integration in row crop landscapes
  - Develop viability of the replicable framework across diversely managed lands
- **Milestones**
  - **Go/No-Go Q2 FY16** – Determines extent of full application

- **Collaborative Work on Watershed Sustainability**
  - SWAT Analysis – ANL/ORNL
- FY14 – South Fork Watershed
- FY15 – Iowa River Basin



SUMMARY

- OVERVIEW
  - Develop innovative model based landscape design methods that forecast increased biomass availability, improve soil, water, and air quality, and reduce grower losses
- APPROACH
  - Utilize natural subfield variability to create opportunity for energy crop integration into row crop landscapes
- PROGRESS & RESULTS
  - Modeled impact in central Iowa, increasing biomass availability by 99%, reducing soil erosion and nutrient loss, and improving organic carbon.
- RELEVENCE
  - Increased biomass availability improves logistics costs, improves system sustainability, and improves grower returns.
  - Products impact growers, biomass end users, and the research community
- FUTURE WORK
  - Expansion of analysis methods across the US
  - Collaborative efforts to understand watershed and bioenergy system impacts
  - Deployment of user-tools to promote data use and impact

THANK YOU

- Questions?

PUBLICATIONS, PRESENTATIONS, & COMMERCIALIZATION

- Publications
  - Bonner, I.J., Muth, D.J., Koch, J.B., Karlen, D.L. 2014. Modeled Impacts of Cover Crops and Vegetative Barriers on Corn Stover Availability and Soil Quality. Bioenergy Research, 7(2).
  - Bonner, I.J., Cafferty, K., Muth, D., Tomer, M., Porter, S., James, D., Karlen, D., 2014 Opportunities for Energy Crop Production Based on Subfield Scale Distribution of Profitability. Energies, 7. pp. 6509-6526.
  - Bonner, I.J., McNunn, G., Tyner, W.E., Leirer, J., Muth, D.J., Dakins, M., 2015. Development of integrated bioenergy landscapes using precision-conservation and multi-criteria decision analysis techniques. Journal of Soil and Water Conservation, In Review.

- Presentations
  - Bonner, I.J., "South Fork Watershed: Collaboration for Improved Land Management" *USDA National Laboratory for Agricultural and the Environment*. Ames, IA, February 2014.
  - Bonner, I.J., "Connecting Integrated Landscape Management with Biomass Feedstock Logistics" *DOE's Integrated Landscape Workshop*. Argonne National Laboratory, IL, June 2014.
  - Cafferty K.G. "Application of Subfield Integrated Landscape Management" *USDA Northeast Woody/Warm-season Biomass Consortium All-hands Meeting. November, 2014.*

- Commercialization
  - LEAF is currently being used by AgSolver Inc. to inform agricultural land managers about subfield management options to improve economic return

Comments from FY13 Peer Review

- It is critical that, moving forward, project Pi's continue active collaboration with USDA's ARS, the NRCS and industry for this potential to be realized.
  - This has always been a goal of this project. It is evident in the publications listed that the collaborations have become even stronger since FY13.

- The plans for future work were grandiose but vague, and should be refined.
  - After the peer review in FY13 it became evident that this project would be best served as a stand-alone project and was split out and given a much more focused goal. Additionally, this project was peer reviewed in FY14 project planning stage to assure that the project goals and resources were properly aligned with BETO goals.