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

U.S. Department of Energy (DOE)
Bioenergy Technologies Office (BETO)
2017 Project Peer Review

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4.2.1.20 Integrated Landscape Management

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Analysis and Sustainability

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Goal Statement

- **Goal**
  - Promote and increase **sustainable production of cellulosic biomass** (plant residue + energy crops) to support bioenergy industry using **innovative landscape design tools and methods**
  - Develop and deploy an **analytical framework** to promote actionable grower- and landscape-level changes that **enhance commercial viability of bioenergy**
- **Outcome**
  - **Using the analytical framework, demonstrate the sustainable production** of 285 million tons/year of cellulosic biomass by 2022 at $84/ton (in 2014$) by 2017
- **Relevance To Bioenergy Industry**
  - Bioenergy industry must have a **long-term, sustainable supply of raw material (biomass)** at prices that can compete with other energy sources

Quad Chart Overview

- **Timeline**
  - Project start date: 10/01/2014
  - Project end date: 09/30/2017
  - Percent complete: 67%

- **Budget**

	FY 15 Costs	FY 16 Costs	Total Planned Funding (FY 17-Project End Date)
DOE Funded	$514.9k	$481k	$550k
Project Cost Share (Comp.)*			

* No cost share on the project.

- **Barriers**
  - St-C: Sustainability data across supply chain
  - St-G: Land-Use and Innovative Landscape Design
  - Ft-A: Feedstock Availability and Cost

- **Partners**
  - Industry Collaborators
    - AgSolver Inc., Antares Landscape Design Project
  - Univ. & Agency
    - USDA-ARS, NRCS

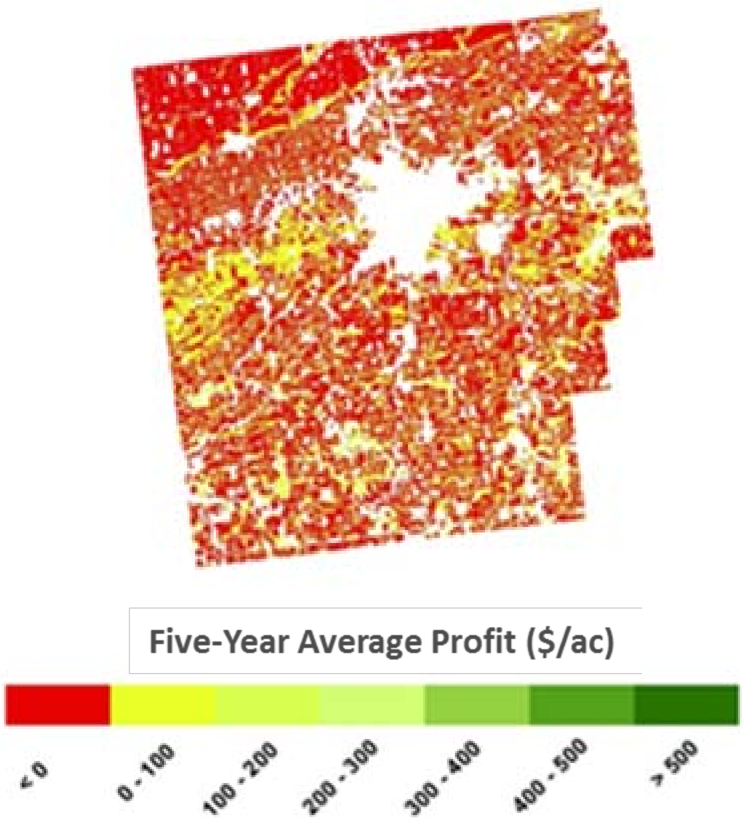
Project Overview

- **History**
  - Project was conceived in 2014 from WBS 1.1.1.2 (Sustainable Feedstock Production – Logistics Interface)
    - Development of **LEAF** (Landscape Environmental Assessment Framework) for assessing **sustainable residue availability**
- **Context**
  - **Gap between leading knowledge and actionable information**
  - Single feedstock and residue systems vulnerable to limitations and risks – environmental impacts, uncertain growing conditions, grower economics
- **Objectives**
  - **Diversify** and increase feedstock availability through **energy crop integration** (increase overall biomass production)
  - Increase **grower productivity and profits**
  - Improve **environmental sustainability** of biofuels
    - Contain soil, soil carbon, and nitrate losses from wind and water erosion and GHG emissions
    - Limit nutrient loading of water bodies through wash-off and overland flow (algal blooms, hypoxia, dead zones – Gulf of Mexico, Lake Erie)
  - Develop **deployable and actionable analytical framework**

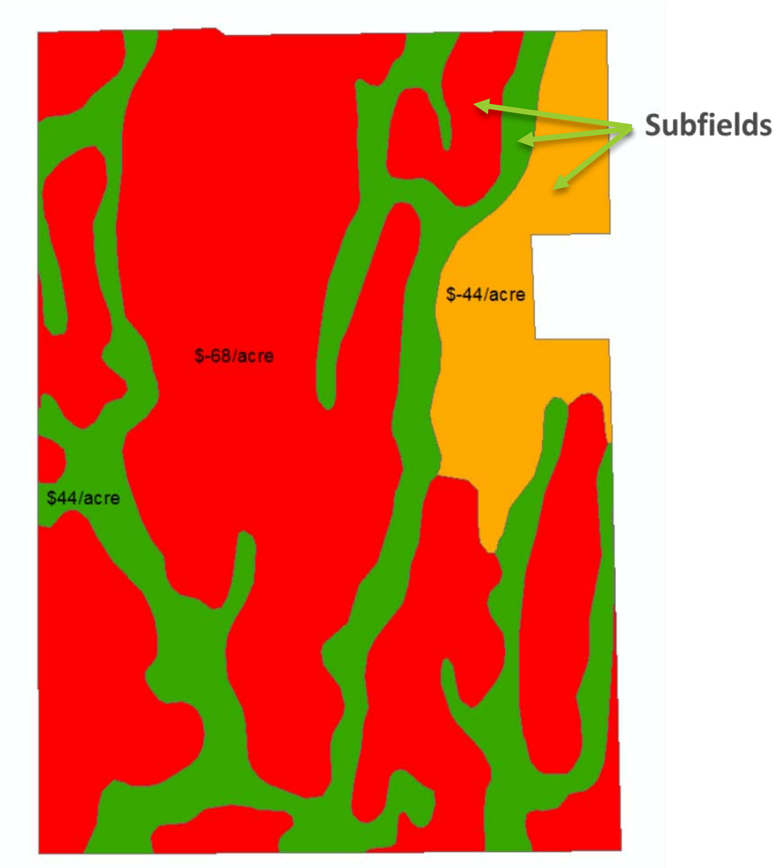
Project Overview (Cont'd)

- **Integration of Energy Crops into Landscapes**
  - Grow energy crops on non-profitable grain subfields
  - Sustainability Criteria: Basic Control: Soil Erosion < T_s; SCI > 0
    Rigorous Control: Soil Erosion < $1/2T_s$; SCI and SCI-OM > 0

Hancock County, OH



A Farm in Hancock County



Project Overview (Cont'd)

- **Current Status**
  - **Several tools developed and tested within the LEAF framework to date for analyses at county and state levels**
    - Crop and biomass yields
      - based on soil, climate, and management practices to control soil erosion and nutrient losses
    - Harvesting methods and costs
      - based on crop, field size and shape, and equipment
    - Multiple crops
      - Databases developed for multiple row and energy crops

  - **Tool set currently being enhanced with AGNPS (AGricultural Non-Point Source Pollution) model to address nutrient losses to surface waters using energy crops**
    - Will allow minimization of nutrient loading to water bodies
    - Will allow strategies to design landscapes with alternate energy crops
      - Energy crop grown on non-profitable subfields
      - Energy crop grown on buffer zones
      - Riparian vegetation growth

Management Approach

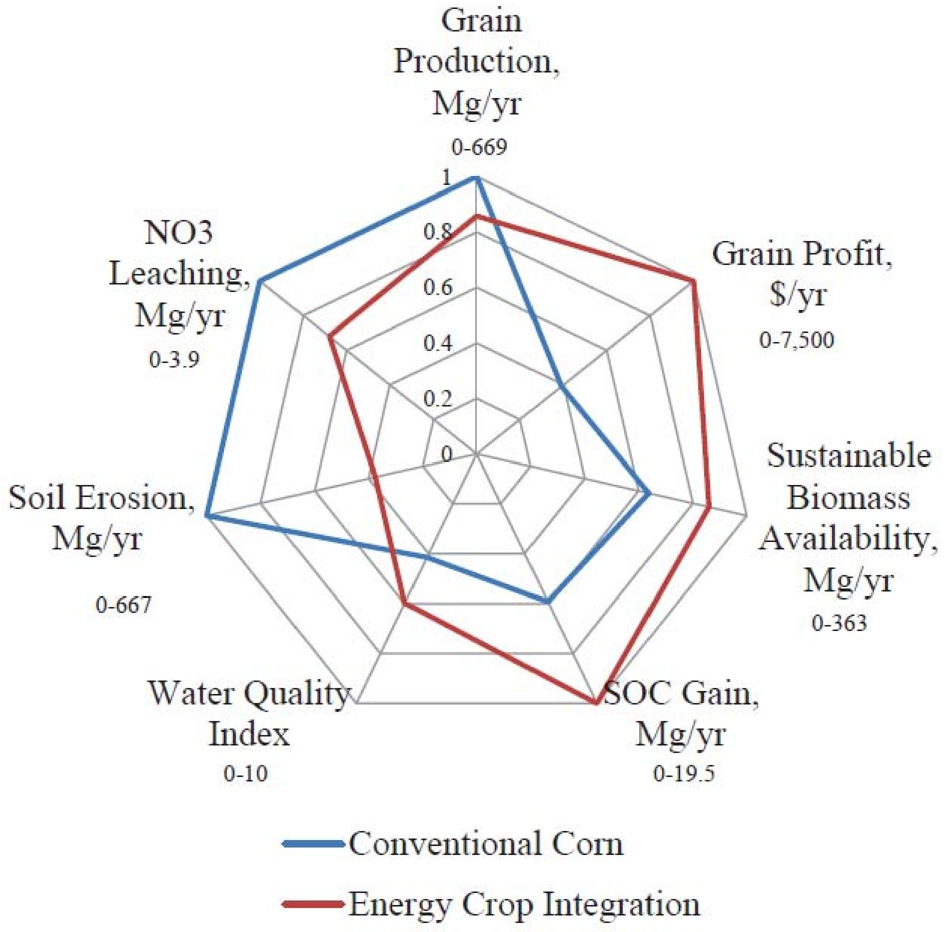
- **Success Factors**
  - **Ability to tie biomass availability and sustainability to feedstock logistics**
    - Quantitative and demonstrative analysis of feedstock procurement
    - Cross-agency and industrial collaborations
      - USDA-ARS and NRCS; Hypoxia Working Group – ORNL, ANL, USDA-ARS, Universities; Antares Landscape Design Project
  - **Repeatable analytical results**
  - Show, through analysis, **increase in overall biomass availability, at lower cost, with incorporation of energy crops and minimal impacts to grain production**
  - **Deployable framework**
- **Challenges**
  - Complexity and quantity of data integration across the supply chain
  - Project cohesion amongst various disciplines (physical, biological, engineering, social, and economic)
  - Ensure products reach key stakeholders (from growers to policy makers)

Technical Approach

- **Replicable Framework**
  - Analysis framework uses well-vetted models
  - **Results are repeatable and location-, scale-, and scenario-specific**
  - **Framework is available to the public**
- **Bottom-up Approach**
  - **Subfield-level granularity with decisions made at farm/field level and higher**
  - Generates impactful and actionable information for growers and policy makers
- **Success Factors**
  - Products must be replicable, deployable, accessible, implementable, and actionable
  - **Advances understanding and design of integrated bioenergy landscapes**
- **Challenges**
  - Capture diversity/variability in management practices and local conditions
  - Data acquisition, validation, and preprocessing
  - Retain framework applicability and validity across multiple scales and regions

Technical Accomplishments

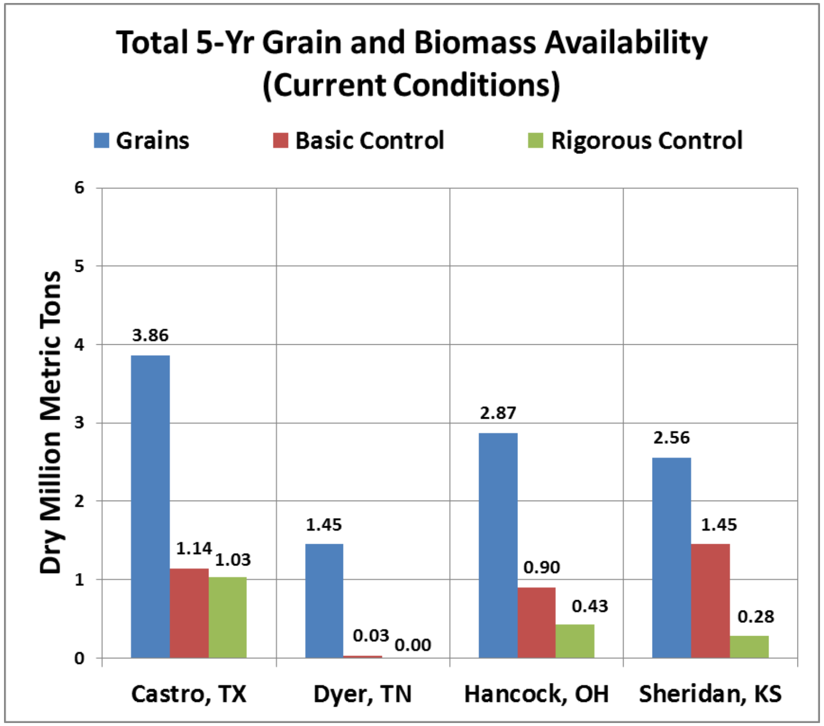
- **FY15**
  - Established high variability in field-level **production and profit**



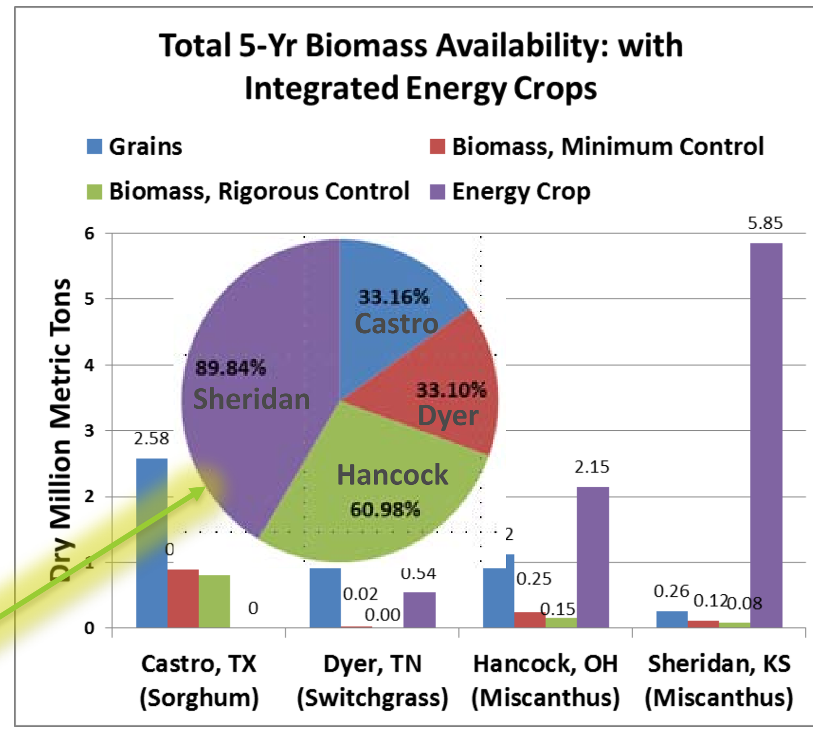
- **FY16**
  - Extended analysis to four counties for studying
    - potential to increase biomass
    - potential to reduce feedstock logistics cost
    - impact on grain production
  - Non-profitable sub-fields replaced with energy crops

Technical Accomplishments (Cont'd)

- **FY16 – Four-County Analysis**



– Increase in biomass: -22% to 2000%
– Most contributions from energy crops
– Variability demands analysis of full states



– Energy crop yields within published ranges (Mitchell et al. 2016)
– Significant reduction in grain production

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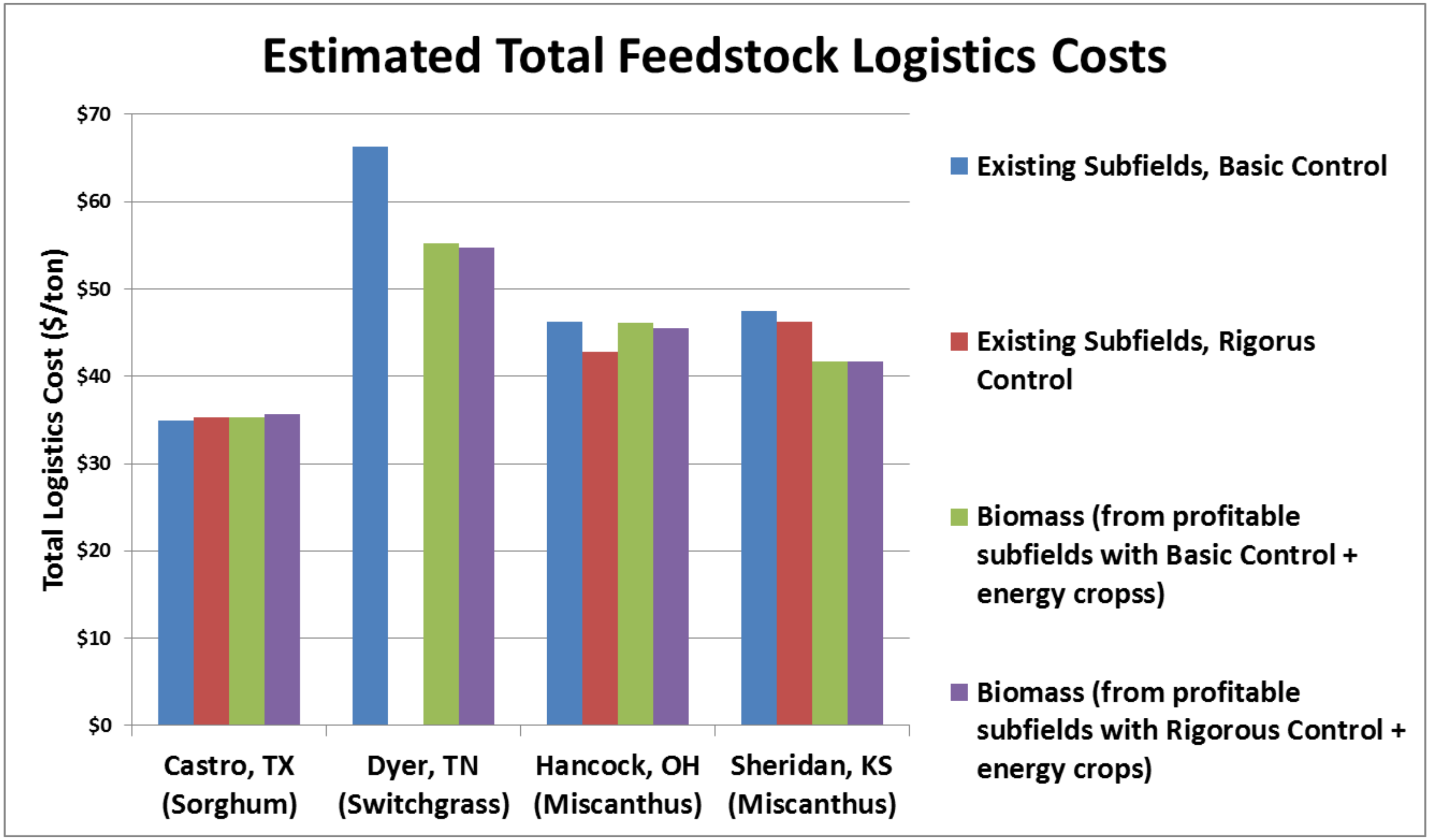
Technical Accomplishments (Cont'd)

- **Four-County Analysis (Cont'd)**
  - With grower's cost of ~$30/ton, integrated biomass production feasible at <$84/ton



Logistics cost does not include grower's cost

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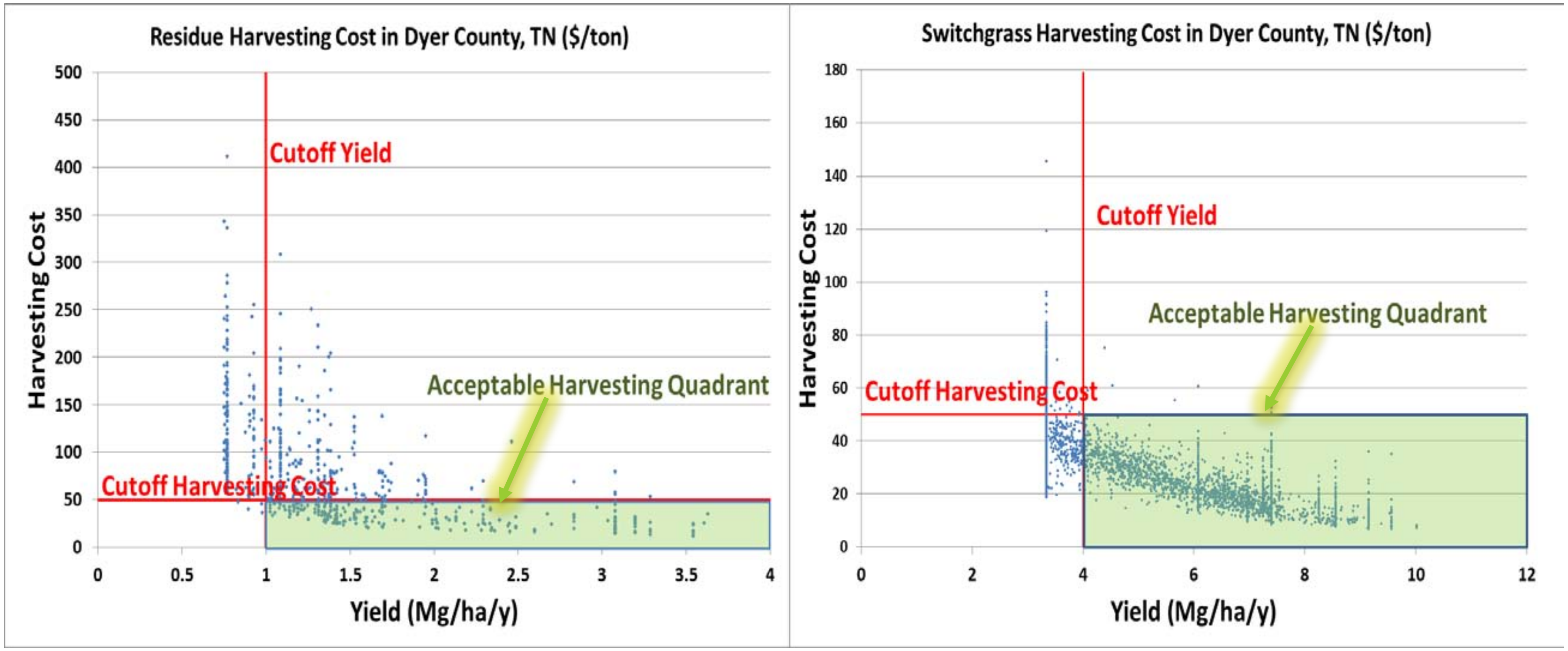
Technical Accomplishments (Cont'd)

- **Four-County Analysis (Cont'd)**
  - Select actionable subfields using minimum yield and maximum cost criteria (green areas in figures below)
  - Modify post-processing to home in on acceptable subfields



Relevance

- **Outputs**
  - **FY15-16**
    - Analyses indicating **increased biomass availability, environmental sustainability, and grower profitability** in four counties in the U.S.
  - **FY17**
    - **Extension of analysis to two states** – KS and IA
    - Effectiveness of bioenergy crops in **reducing nutrient loading** to surface water bodies
    - **Deployable framework**
- **Stakeholders**
  - **Land managers –** support for **precision agronomics** and **reduced risk**
  - **Researchers –** address high-level biomass availability and row-crop depletion concerns
  - **Industry –** information on **biomass supply and strategy**, and **economic opportunities**
  - **Policy makers –** clear communication of pathways to achieve biomass production and land stewardship

Relevance (Cont’d)

- **Impacts**
  - Advance state of technology on actionable landscape design and planning and implementation
  - Development of robust and flexible datasets, analysis tools, and recommendations to meet the diverse stakeholder needs
  - Critical, forward looking support for developing environmentally, socially, and economically sustainable practices for biofuel production

Future Work

- **FY17 – Expansion of Analysis to Two States**
  - Energy crop integration in row crop landscapes
  - Establish viability across diverse and diversely managed lands
  - Demonstrate reduction in watershed nutrient loading through energy crop integration
  - Develop and deploy web-based tool set, data sets, and analysis results
- **Beyond FY17**
  - Add additional analyses to the tool set for comprehensive projections
    - Analyze multiple management scenarios and diverse landscapes – **assess buffer zones and riparian areas**
    - Develop grower-level **water, nutrient, and energy use budgets** to show effective implementation of Food-Water-Energy nexus principles
    - Include **transportation analyses** for feedstock supply systems
    - Develop and include correlations between **management options and feedstock quality**
    - Include **monetization of ecosystem services** to promote bioeconomy
    - Enable assessment of **water quality trading credits**
    - Provide access to tools, datasets, and methods to stakeholders

Summary

- **Progress & Results**
  - **Four-county analysis shows feasibility** of sustainable integration of energy crops into row crop fields at costs meeting BETO 2017 goals
- **Relevance**
  - Integrated landscape management tools developed to **promote actionable** grower- and landscape-level changes that could **enable green bioenergy** production to compete with alternate fossil fuels
- **Lessons Learned**
  - **Analysis of spatial variability needed for impacts and insights**
    - Apply framework across multiple states and regions
  - **What can motivate a grower to integrate bioenergy into his field?**
    - Profitability from integration of energy crops
    - Monetization of ecosystem services
      - Identify ecosystem services from water quality improvements and crop diversity
      - Monetize and develop strategies to direct benefits to farmers

Thank You

Questions

2015 Peer Review Comments

- **Comments and Resolutions**

  - Project seems to overlook operational cost implications of subfield work…
    - Harvesting costs now reflect the shape and size of subfields and equipment used for both residues and energy crops

  - Project seems to assume that bioenergy is justified on any area that is losing money…
    - Post-analysis selection of subfields for residue and energy crop harvest based on cutoff yields and operational costs facilitates bioenergy production planning with individual grower in mind

  - Getting this tool out to farmers critical…
    - While tools, analyses and data sets still being developed and assembled, final goal remains the deployment of the entire tool set, data set, results of analyses, and recommendations
    - An earlier version of the tool has been commercialized (AgSolver)