Opportunities for Farmers in Biomass Feedstock Production

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Getting into the Biomass Business

Crop Residue Removal; Farm Budget Plan Example

Farm Statistics and Management Practices:

- 1700 acres (1200 acres wheat, 500 acres potatoes)
- 3 year crop rotation (wheat, wheat, potatoes)
- If harvested, 1 ton / acre straw removal
- Straw Contract Price ($10-$15 / ton in the field)

Straw agronomic value is offset by elimination of residue management

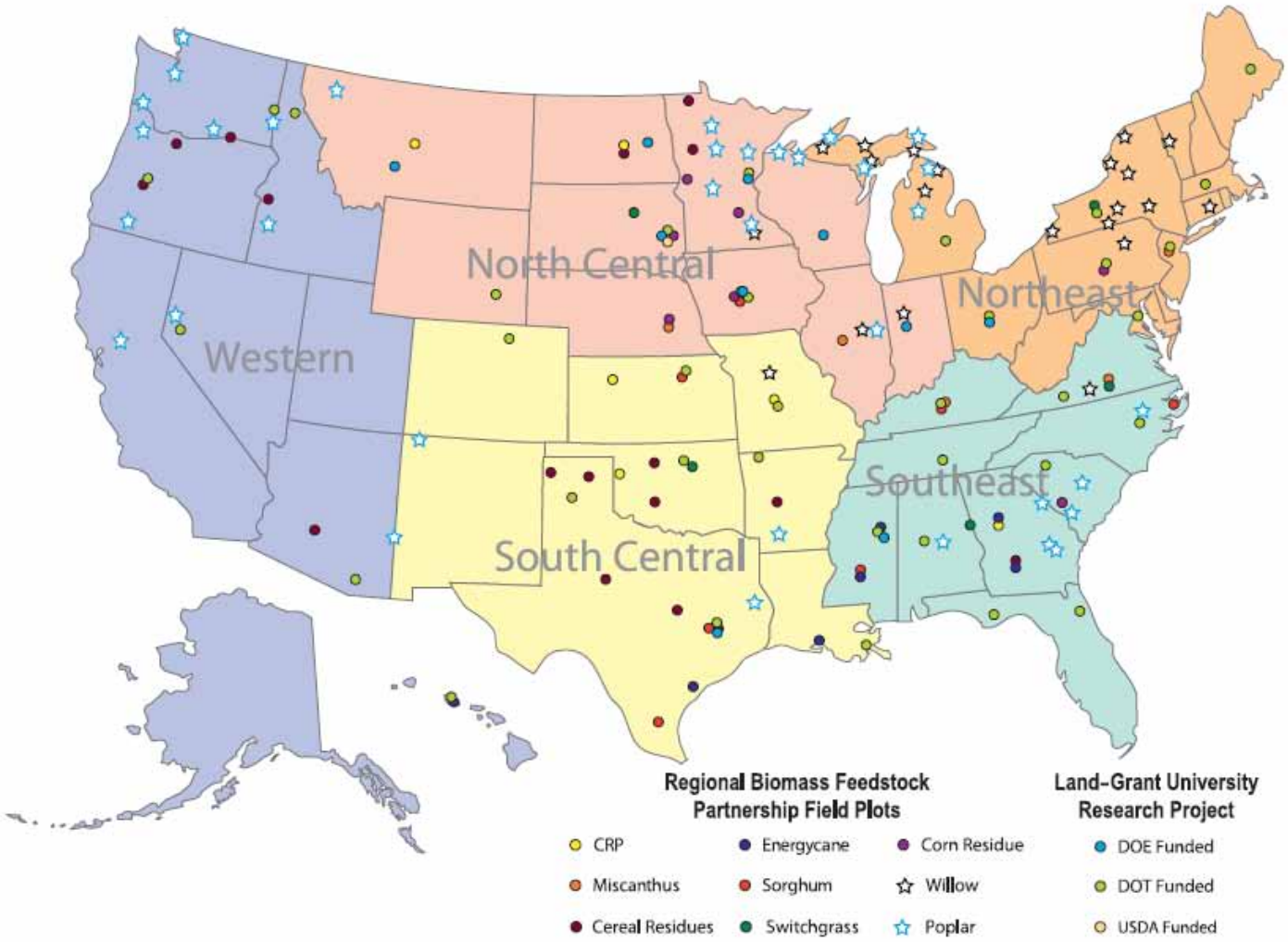
Crop Rotation Removal Point	Tons Harvested	Removal Net Cost Impact	Biomass Revenue	Farm Net Returns
No Biomass Removal	0	($2,800)	$0	14.0%
Wheat-Wheat Removal	700	$0	$7,000	14.6%
Wheat-Potato Removal	500	($19,927)	$5,000	12.7%
All Wheat Removal + Manure on Potato Ground	1,200	($2,500)	$12,000	14.8%

Potato yield impact

$10/ton straw value adds the equivalent of $0.10/bu to the wheat crop gross returns

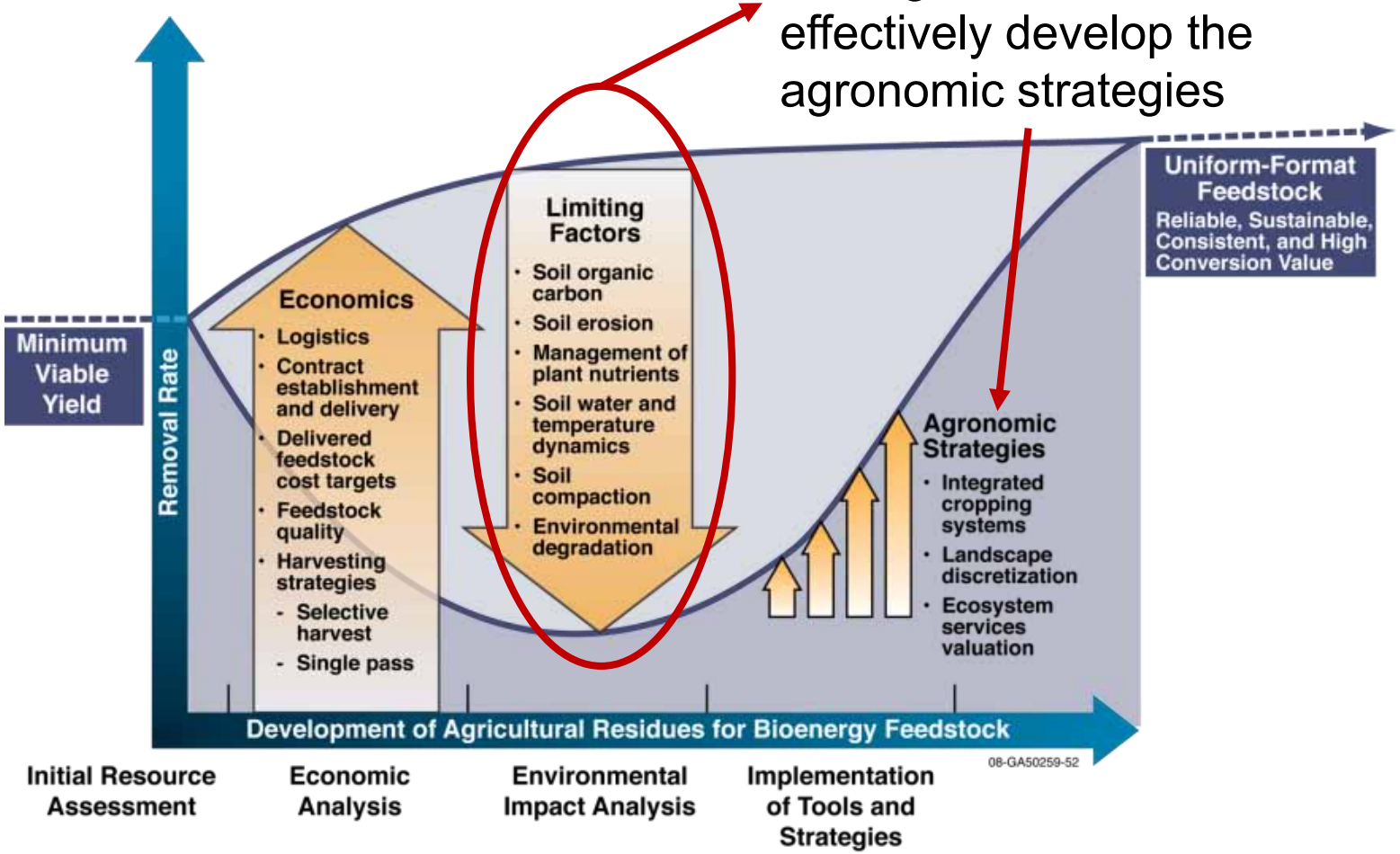
Knee high windrow means good to go

Regional Biomass Feedstock Partnership



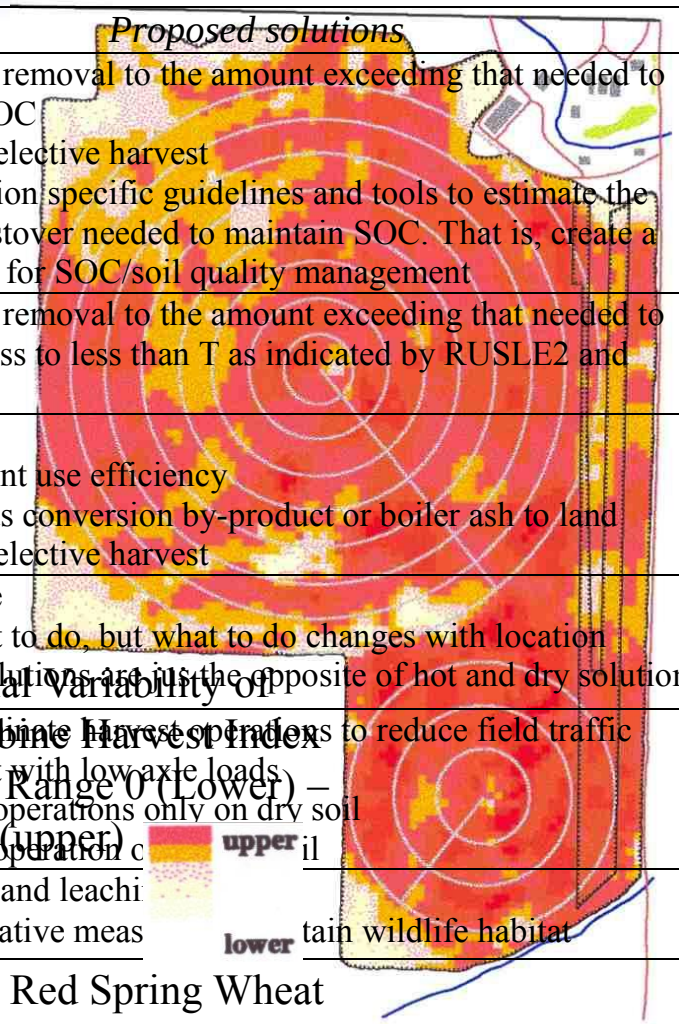
Residue Harvest Paradox

Focused on quantifying the limiting factors, so we can effectively develop the agronomic strategies



Agronomic Factors Limiting Crop Potential

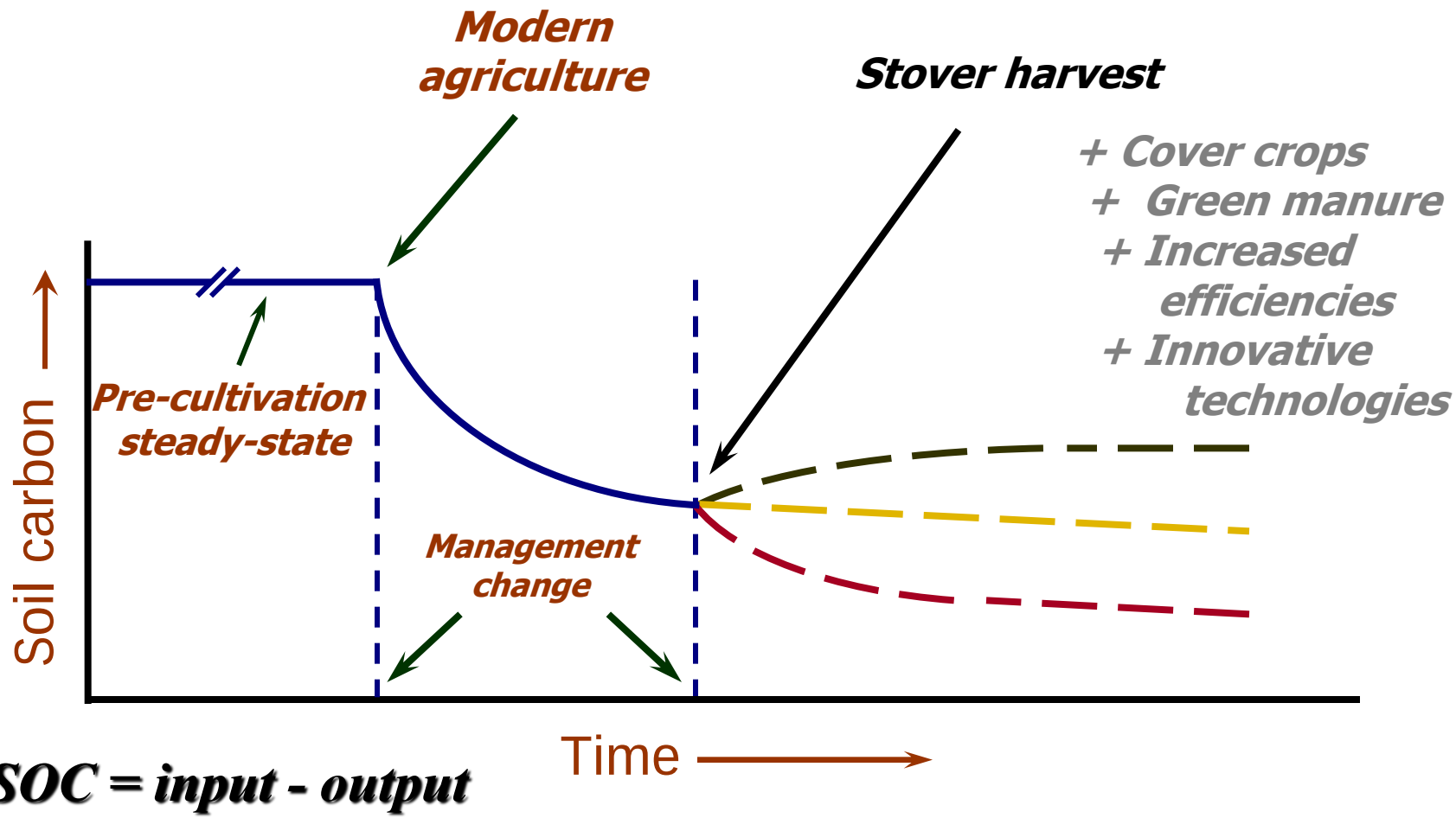
Limiting factor	*Issues*	*Proposed solutions*
Loss of soil organic carbon	Supply/replenish SOC Soil quality Future production capacity	Restrict stover removal to the amount exceeding that needed to maintain SOC Fractional or selective harvest Develop situation specific guidelines and tools to estimate the amount of stover needed to maintain SOC. That is, create a "RUSLE2" for SOC/soil quality management
Soil erosion	Water erosion and runoff management Wind erosion management Off-site effects	Restrict stover removal to the amount exceeding that needed to keep soil loss to less than T as indicated by RUSLE2 and WEPS
Loss of plant nutrients	Increased fertilizer application and production costs or reduced crop yield and producer income	Retain stover Improve nutrient use efficiency Return ligneous conversion by-product or boiler ash to land Fractional or selective harvest
Soil water and temperature dynamics	Complex interactions Condition-specific solutions necessary	Need help here We know what to do, but what to do changes with location cool wet solutions are just the opposite of hot and dry solutions
Soil compaction	Compaction of soil due to increase field traffic for residue removal and/or transition to no-till cropping system	Reduce or eliminate harvest operations to reduce field traffic Use equipment with low axle loads Conduct field operations only on dry soil Conduct field operation c il
Environmental degradation	Off-site erosion impacts Nutrient loss to surface water	Reduce runoff and leachi Develop alternative meas tain wildlife habitat



- Spatial Variability of Combine Harvest Index
- Data Range 0 (Lower) – 0.75 (upper)
- Hard Red Spring Wheat
- Ashton, ID - 1996

Crop Organic Matter return rate recommendations (or biomass input) must be managed just like fertilizers and other crop production inputs

Sustainable Residue Removal



$$\Delta SOC = input - output$$

Fractional Single-Pass vs. Mow and Rake

- Single-pass High cut harvested 72% of stover produced (i.e., 12% more stover collected per acre than billion ton study assumptions), so
- 70% removed with combine
  - Low moisture
  - Reduced pretreatment severity
  - Marginal soil half-life (Kumar and Goh, 2000; Eiland et al. 2001)
- 30% of stalk left behind
  - High moisture
  - Highly recalcitrant
  - Long soil half-life
- 40% removed with mow and rake – mostly stalk material

Large Scale Assessment: Spatial Discretization

Adair County, Iowa
212 Kennebec Silt Loam 0% to 2% Slope

1.25 Miles

10 Year Average Yield: Management + Removal Rate	Calculated Erosion	SCI OM Subfactor	Annual Average Residue (lbs)	Corn Grain Yield
Continuous corn grain; NT, Harvest grain and cobs	0.1660717	0.320423	1891.345	149.9
Continuous corn grain; NT, High residue Harvest	1.1931644	-0.60299	7070.866	149.9
Continuous corn grain; NT, Moderate Residue Harvest	0.2281336	0.13634	2905.457	149.9
Continuous corn grain; NT, Moderately High residue Harvest	0.5972384	-0.12565	4542.535	149.9
Continuous corn grain; NT no stover harvest	0.0889718	0.784717	0	149.9

Implementing Sustainable Harvest : Sub-field Scale Variability

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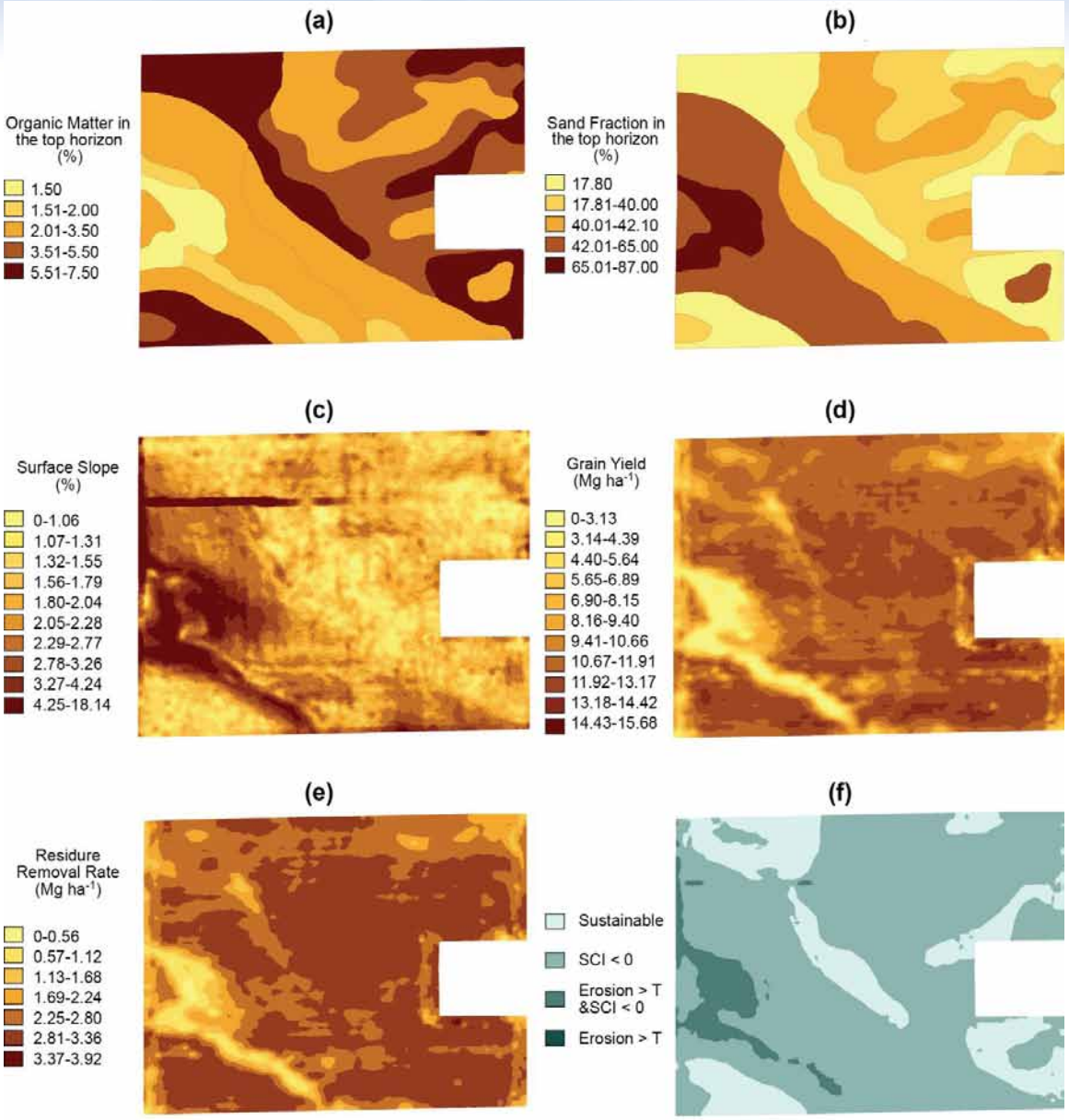
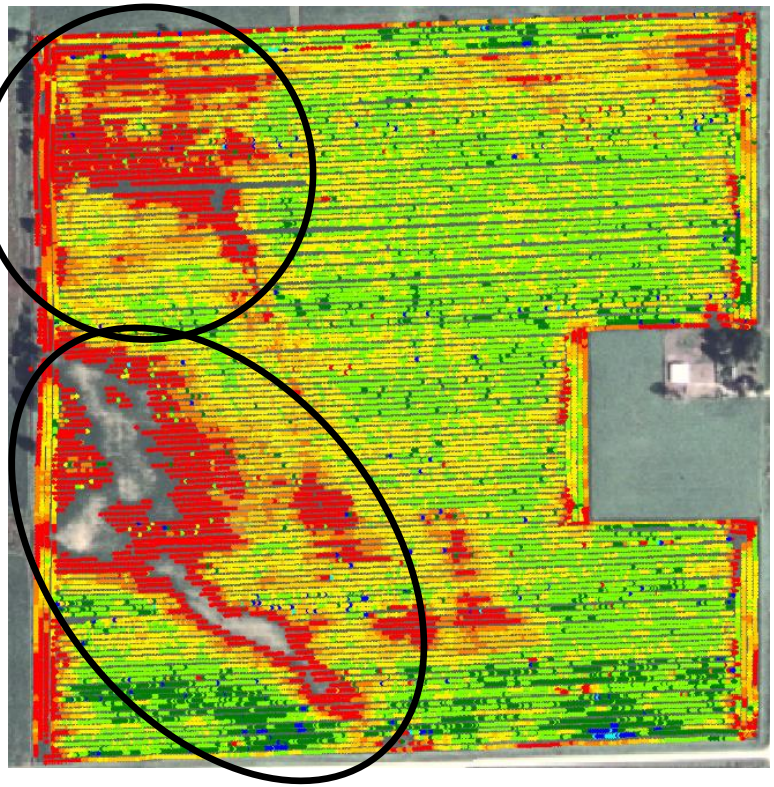
- Diversity in soil characteristics is significant
- Impacts yield
- Creates compounding effects on sustainable residue removal potential



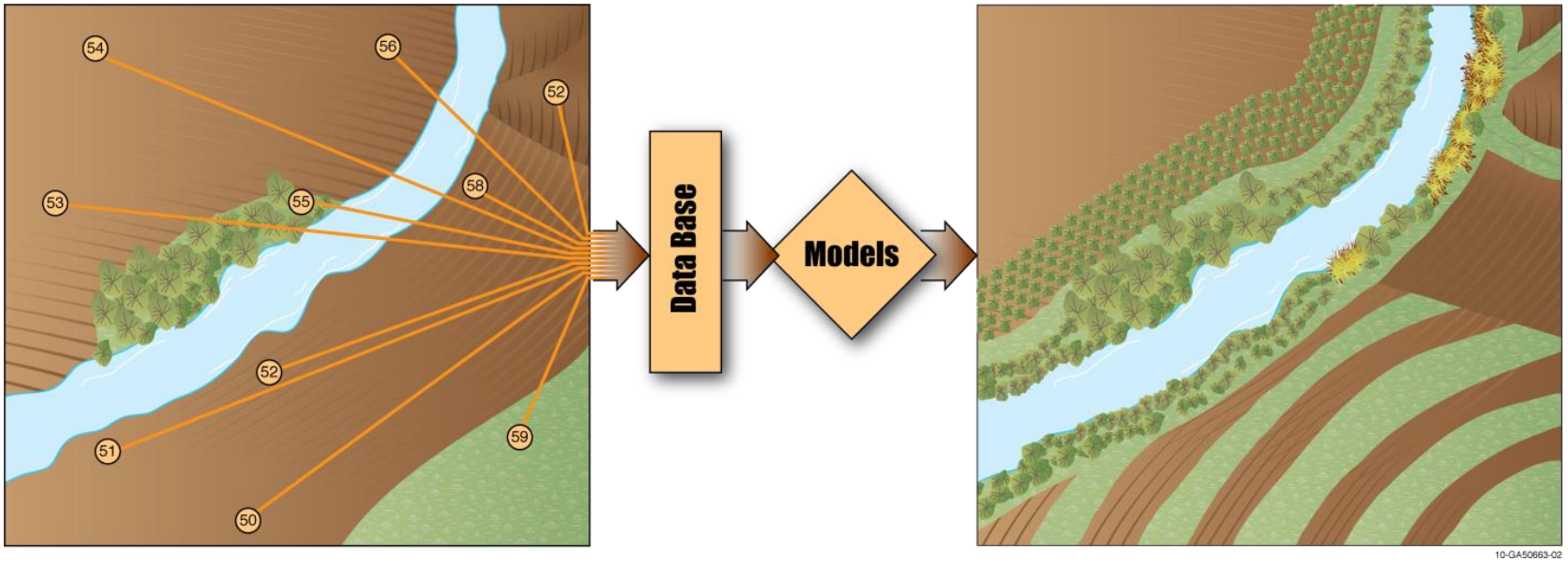
Implementing the Landscape Vision: Viable Entry Points for Dedicated Energy Crops

- Considering direct constraints
  - Unused
  - At-risk
  - Economic Benefits

- Take advantage of indirect constraints
- Rely on existing markets
- Positive operating costs impacts
- Aggregate production
- Incremental step toward the landscape vision



Implementing the Landscape Vision: The Role for Integrated Modeling, Data Management, and Visualization



- Integrated computational systems provide:
  - A path for limited experimental data to be generalized
  - Quantification of ecosystem services for emerging markets
  - The medium for in-field data to be extended to decisions
  - An opportunity to more comprehensively explore the solution space and find innovative landscape configuration solutions

Creating Opportunities for Farmers in Biomass Feedstocks

Long hours and determination

Energy Crop Production Experience

Developed, established, and managed the country's largest acreage of a purpose grown energy crop. Now entering the 5th year of production, energy crop production systems are ready to scale.

- Contracting with local farmers to produce >5,100 acres of switchgrass
  - Completing 4th growing season
  - >60 farmers under contract
  - In 9 counties within 50 miles of Vonore, TN
  - 1,000 acres of improved varieties
- >90% establishment success in 1st year, 100% 2nd year
- Harvesting 8 tons/ ac in 3rd year and after
  - ~2 tons in year 1
  - ~5 tons in year 2
  - ~8 tons year 3 and beyond
- Switchgrass has been a good fit for landowners and farmers
  - Ready and willing to scale to commercial levels

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Delivering Sustainable Biomass Solutions

Cellulosic Ethanol Biorefinery & PDU

- Partnership with DuPont Danicso Cellulosic Ethanol LLC
- Operating demonstration scale plant and PDU successfully since January 2010
- Started operations on corn cob; operating currently on corn stover
- Have begun to process switchgrass in PDU
- Ethanol produced in Vonore supplying E-85 to UT Motor Pool fleet
- DuPont recently finalized ~$7 billion acquisition of Danisco
- Recent announcement of first DDCE commercial scale project in Iowa

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