

# Developing Sustainable Feedstock Production Systems



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# The Driving Force...

## Record Energy Prices

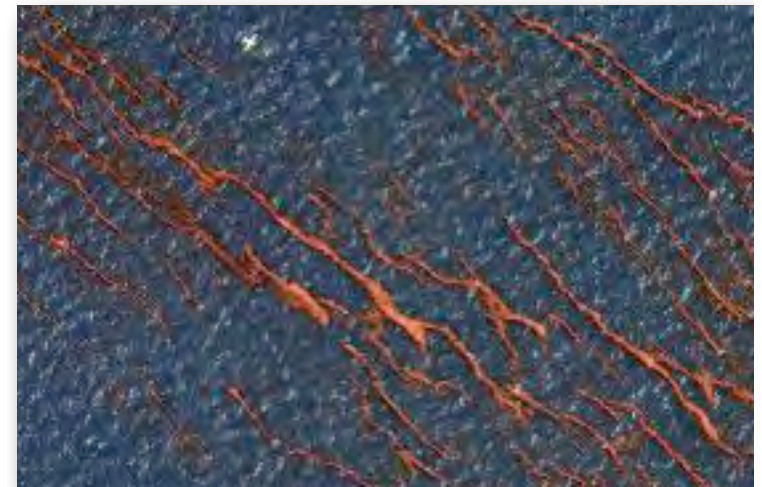
Reflects increased demand from China and India  
Elevates national security concerns  
U.S. accounts for 25% of consumption, but holds only 3% of reserves  
60% of reserves are in unstable regions

## Economic Prosperity

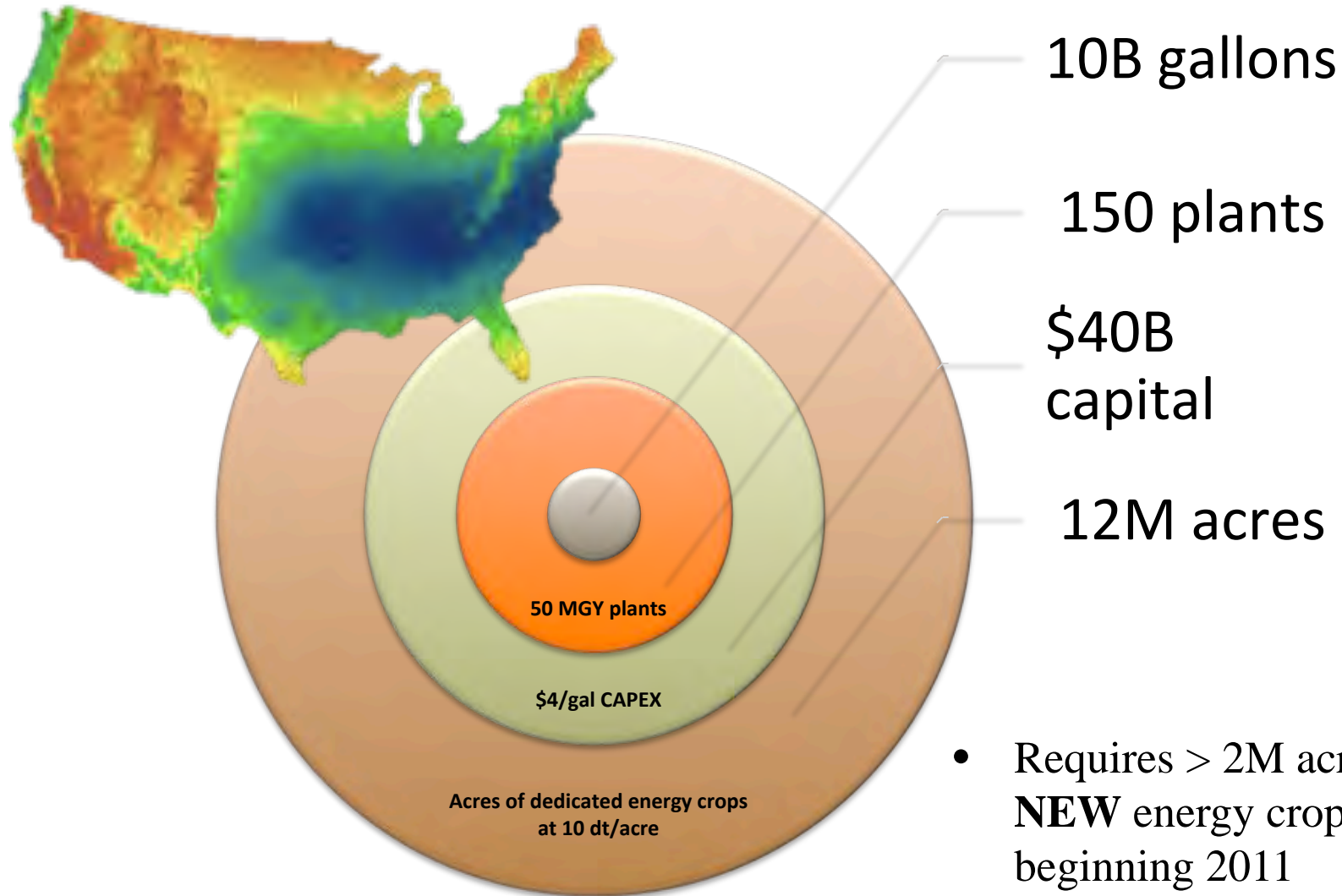
In 2004, the ethanol industry added over \$2B in additional tax revenue  
Projected to add 15,000 jobs for every billion gallons  
Greater impact on rural economy

## Environmental Sustainability

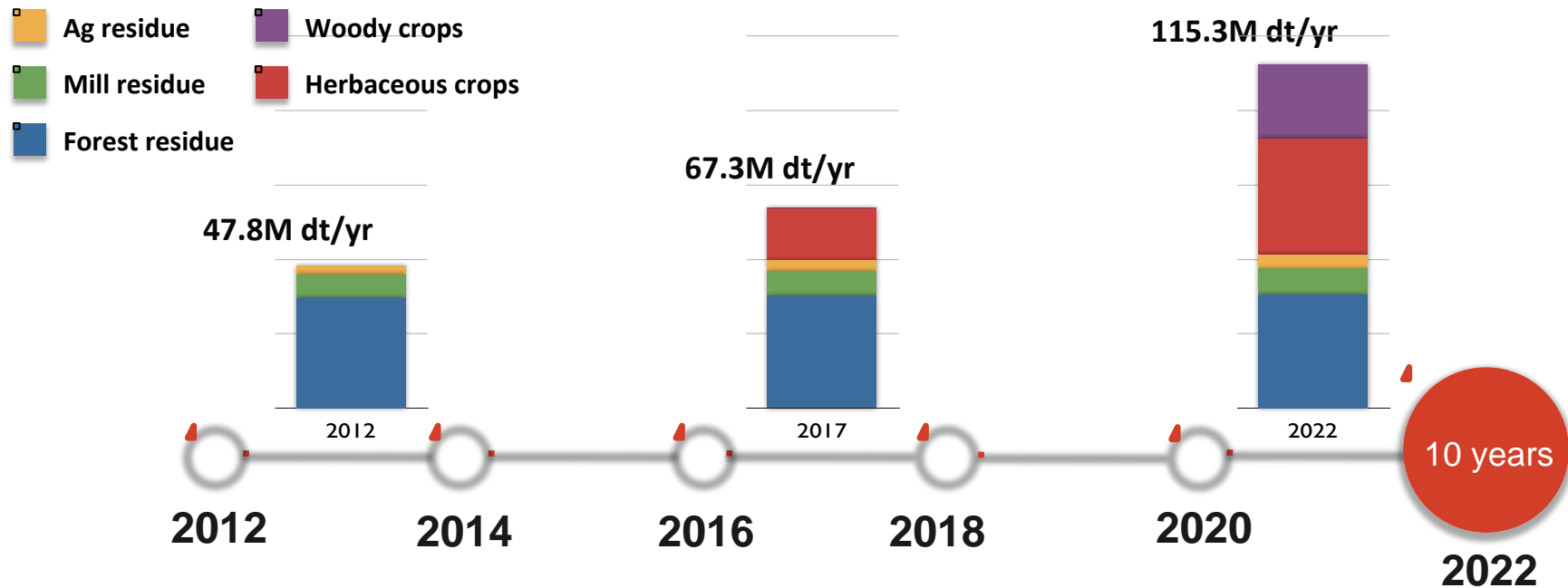
Projected Fossil Energy Ratio of 10.3 compared to 0.81 for gasoline  
A renewable source of carbon energy



# Meeting RFS2 Targets: The Southeast



# The Southeast's Biomass Mix



## Billion Ton Update

U.S. Department of Energy. 2011. *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*. R.D. Perlack and B.J. Stokes (Leads), ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge, TN. 227p.

## 9 Southeastern States

Includes Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

## Assumptions

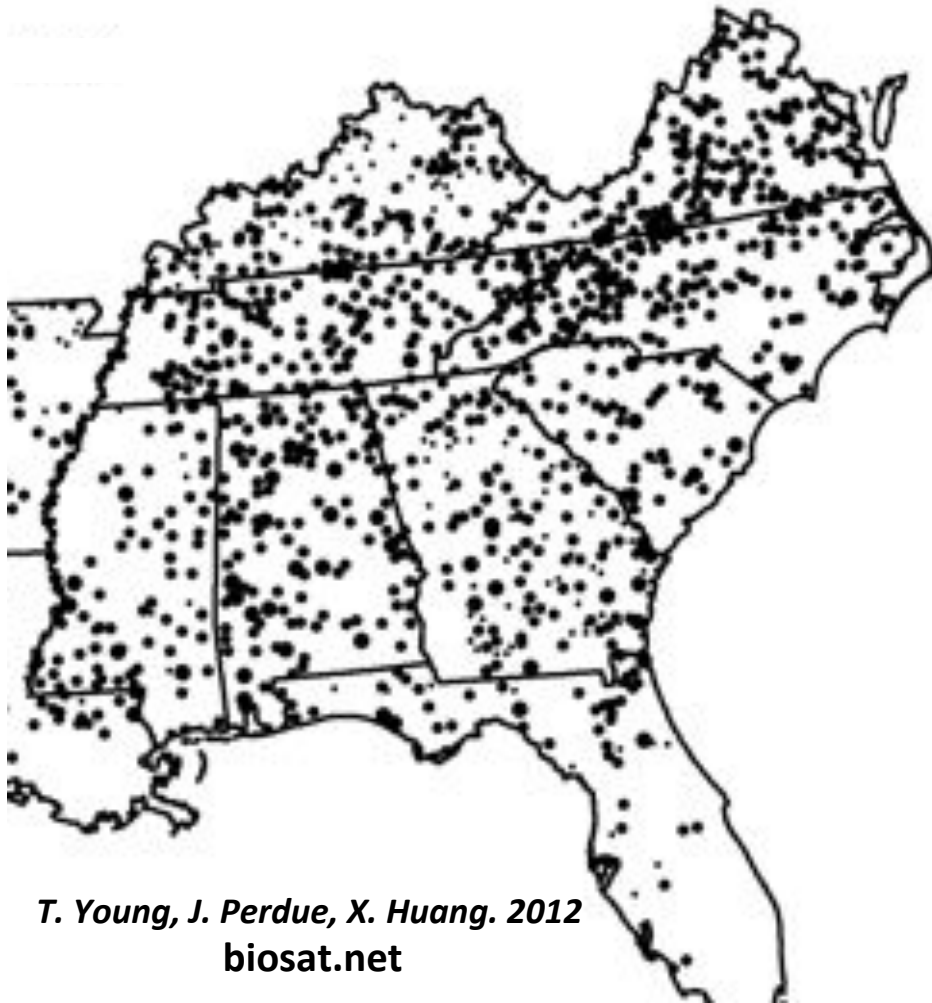
- Base scenario (1% annual yield increase for energy crops)
- \$60/dry ton
- Mill residues and MSW combined

# Today's Feedstock... Southern Pine!

- More than 30 million acres of commercial plantations
- culture
- Requires the feedstock flexibility of thermo-chemical conversion
  - A “heterogeneous” mix of biomass
  - Recalcitrance an issue
- Not a “low-cost” biomass source



# The Southeast's Existing Biomass Industry



*T. Young, J. Perdue, X. Huang. 2012*  
biosat.net

- An extensive forest products industry is in place
- Necessary to generate wood residue (harvest and process)
- Currently very efficient in their use of low-quality material
- Significant contraction with the economic downturn
- The potential for industrial synergy exists

# Important Contributions from Grasses

- A portfolio of crops are available:
  - Switchgrass
  - Sorghum
  - Miscanthus
  - Arundo donax
- Annuals and perennials address landowner and landscape differences
- Rapid improvement in yield through breeding and molecular genetics
- Better performance in biochemical conversion technology



# Short Rotation Woody Crops

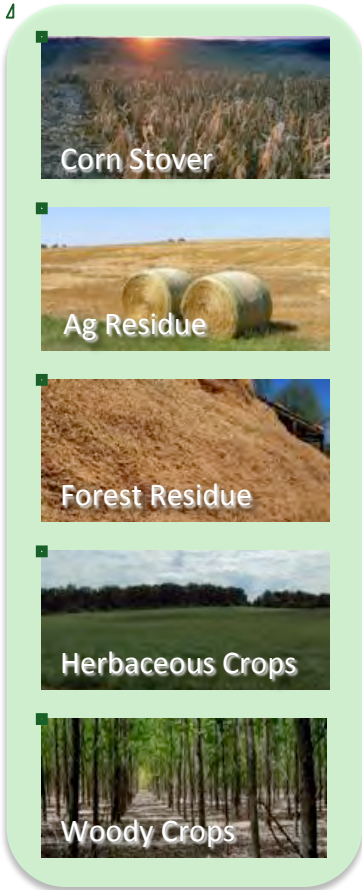
- A potential portfolio for the region
  - Hybrid poplar
  - Eucalyptus
  - Sycamore
  - Sweetgum
  - Loblolly pine
- Relatively new to the southeast as an energy crop
- Performs well in biochemical processes
- Rapid improvement in traits are possible
- Reduces annual supply risks





# Regional Feedstock Partnership

## Feedstock Categories



# Multiple Biomass Crop Systems



Sorghum, Switchgrass, Woody crops,  
Wood residue

Feedstock

Diverse sites, insect/disease, variable  
climate

Supply Risk



Options to meet diverse landowner  
interests and goals

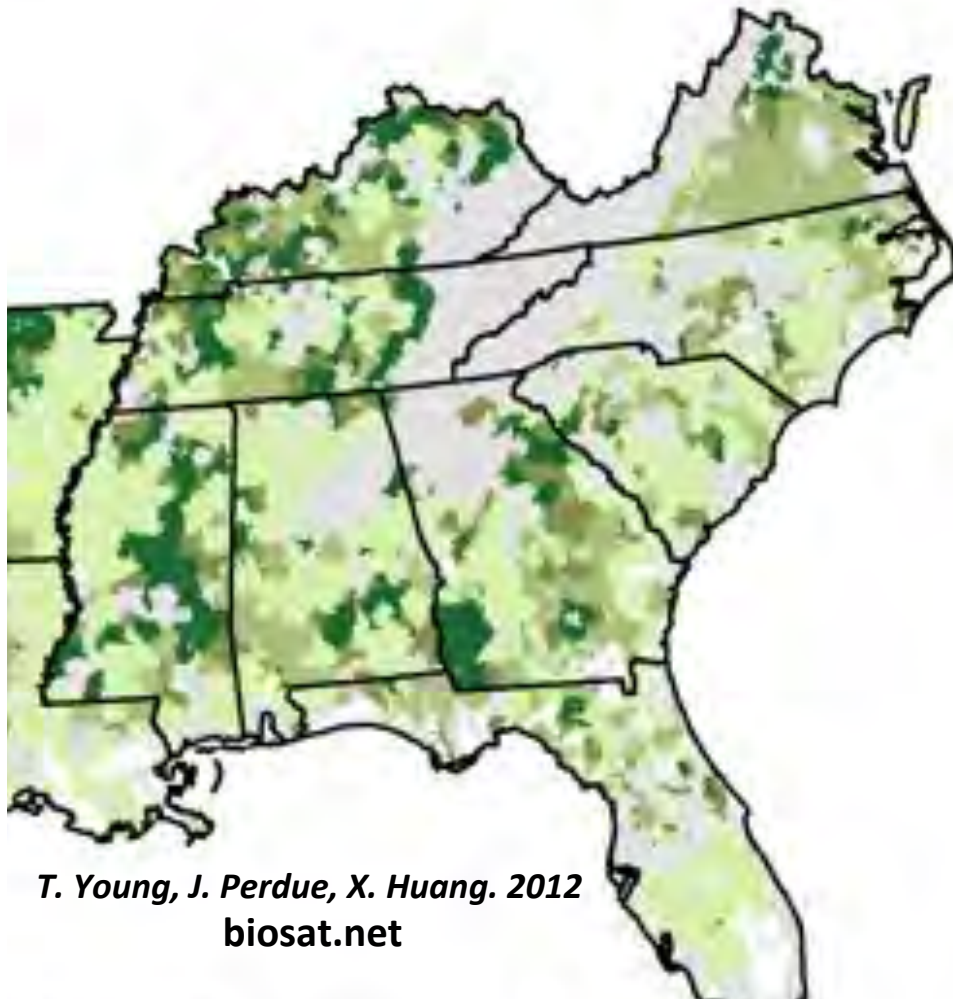
Producers

Flexibility for land stewardship

Sustainability



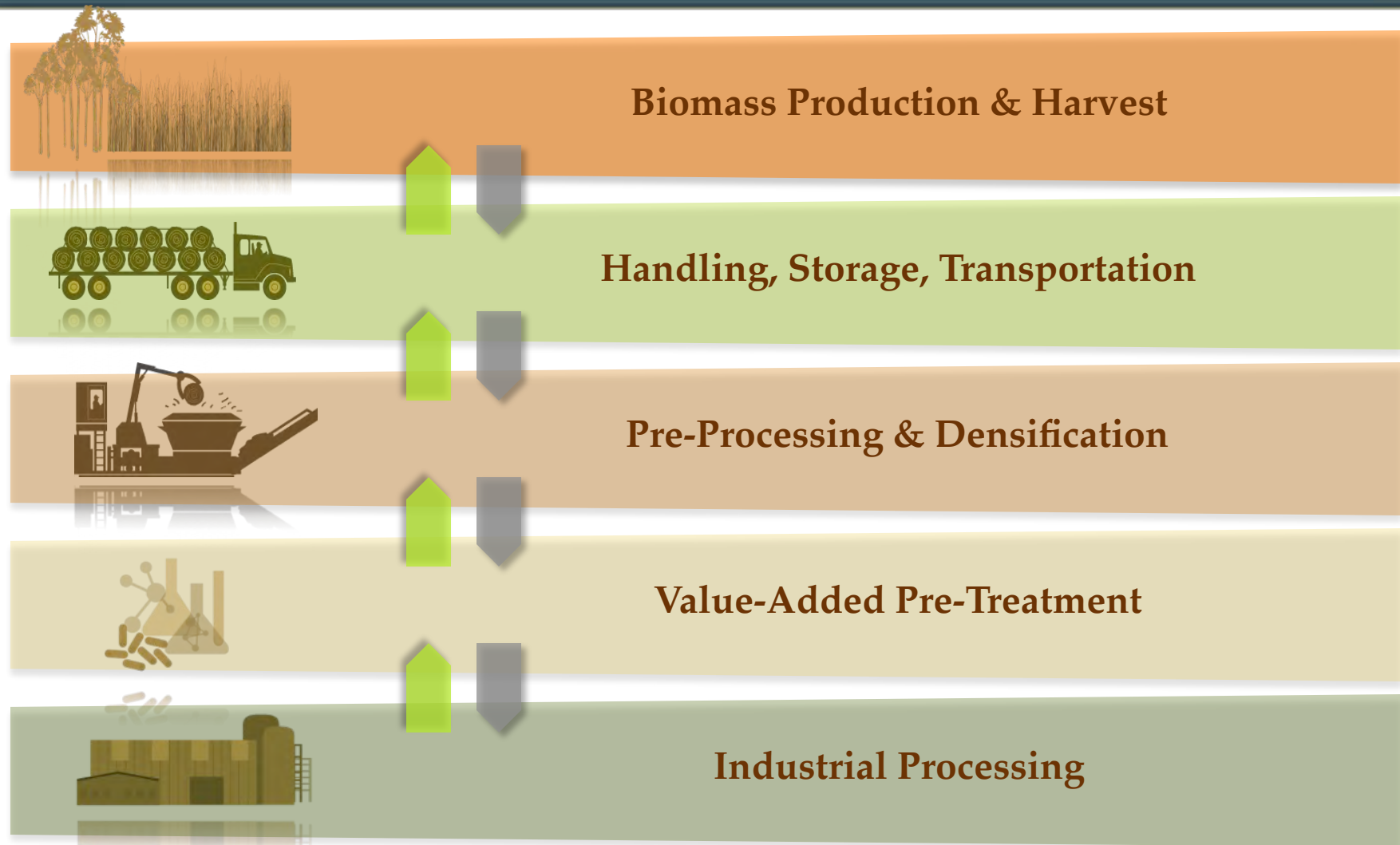
# 30 Million Acres of Pine Plantations!



- Energy crop plantings will require additional, non-pine land

- ◻ Excluded Land (Federal, high population, etc.)
- ◼ Forest sites
- ◼ Forest/Ag flex
- ◼ Ag/Forest flex
- ◼ Agricultural land

# Integrated Biomass Supply Chain



# Switchgrass as an Energy Crop



- Warm season, native, perennial grass
- Well suited to the Southeast
  - Currently, ~6-10 tons/acre in TN
  - Potential for 12+ tons/acre
- Tolerates poor soils, flooding, drought
- Low input use
  - No irrigation, 60 #/ac N, no P & K, no pesticides or fungicides, minimal herbicides
- 1-2 year establishment
  - Weed control critical in establishment
- Works with existing infrastructure
- Noninvasive, may be removed, improves soil quality
- UT research focus for 20+ years



ArborGen ♦ Auburn University ♦ Ceres, Inc. ♦ NC State University ♦ University of Georgia ♦ University of Tennessee



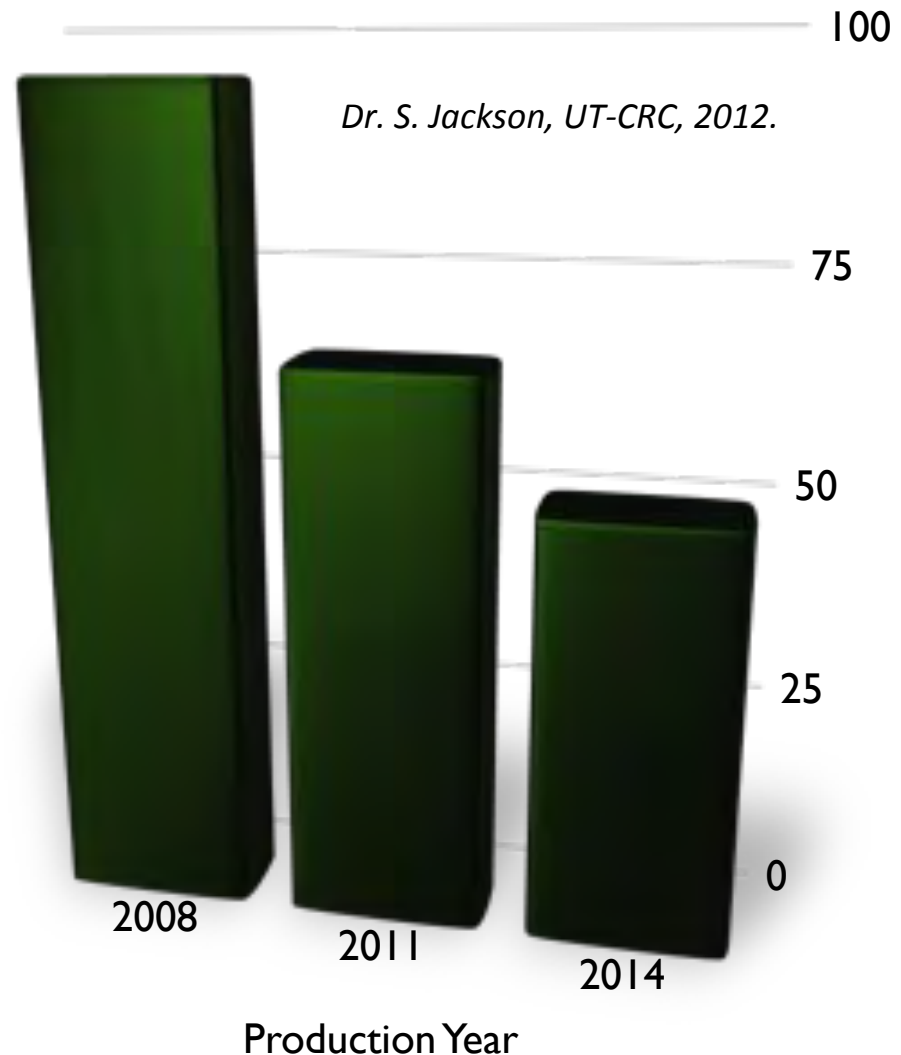
# From Biomass To Feedstock



- 5000 acres of switchgrass under production on private farms
- Biomass depot for storage, handling, and preprocessing
- 250k gallons/year biorefinery producing cellulosic ethanol

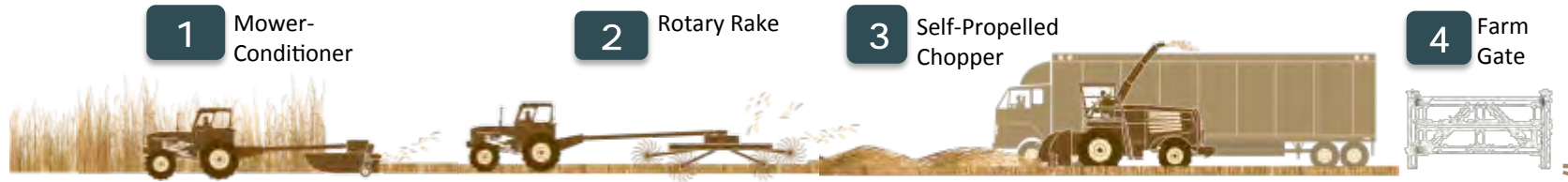
# Switchgrass Delivered Cost (\$/dry ton)

- Significant reductions in establishment costs in 2011
- Improved survival rates
- Project reductions due to:
  - Increase in biomass yield
  - Biomass handling automation
  - Standardization of delivered package





# Commercial Bulk Handling System

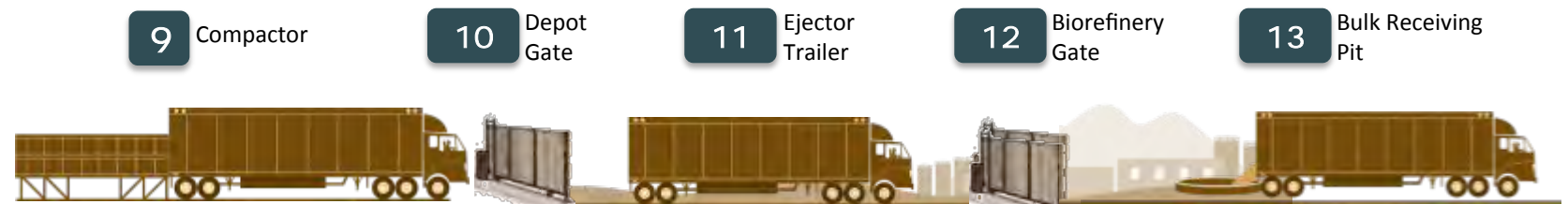


In-Field Harvest & Collection



Transport to Depot

Depot Receiving, Bulk Storage & Reclaim



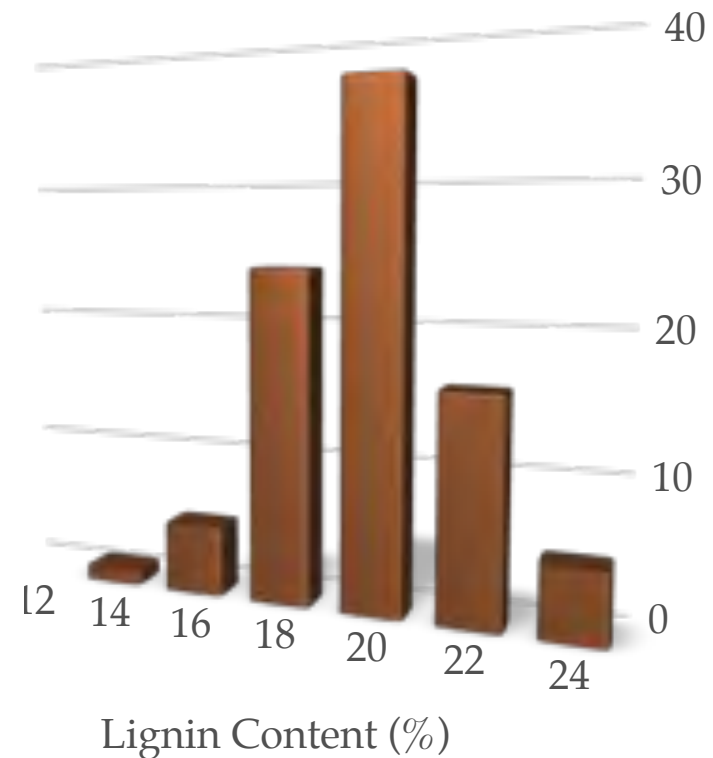
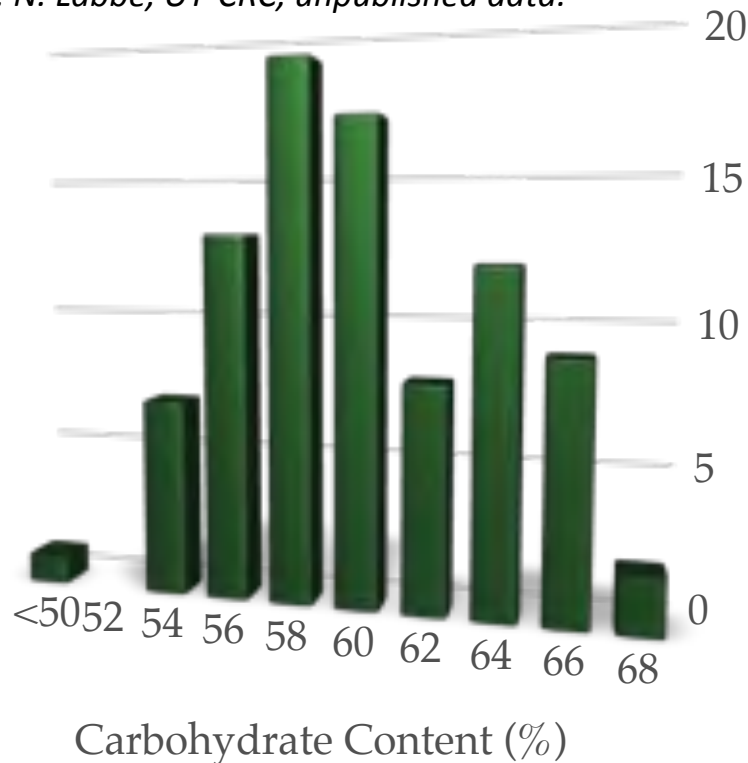
Depot Compaction & Transport to Biorefinery

Biorefinery Receiving



# Exploiting Natural Variation

*Dr. N. Labbe, UT-CRC, unpublished data.*



- Important to recognize that the goal is a feedstock for chemical processes and products.

- Online monitoring provides a first step at feedstock refining through screening for desired traits.

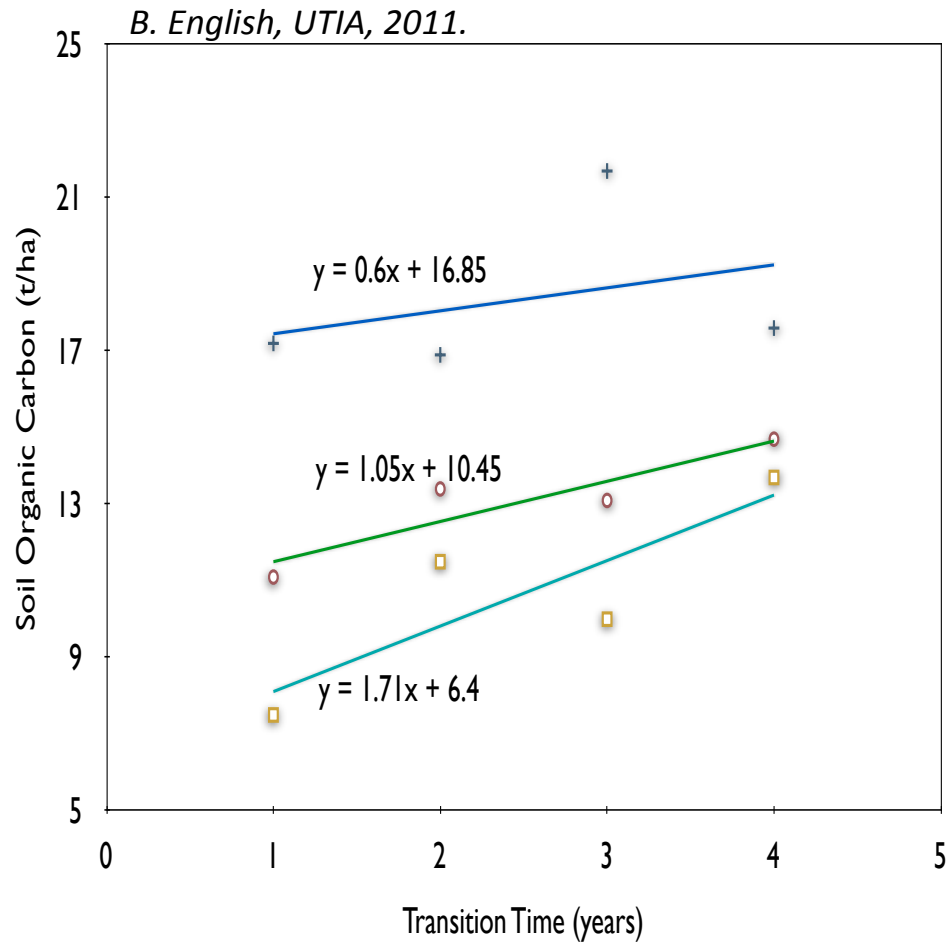
# Sustainability Is Paramount!

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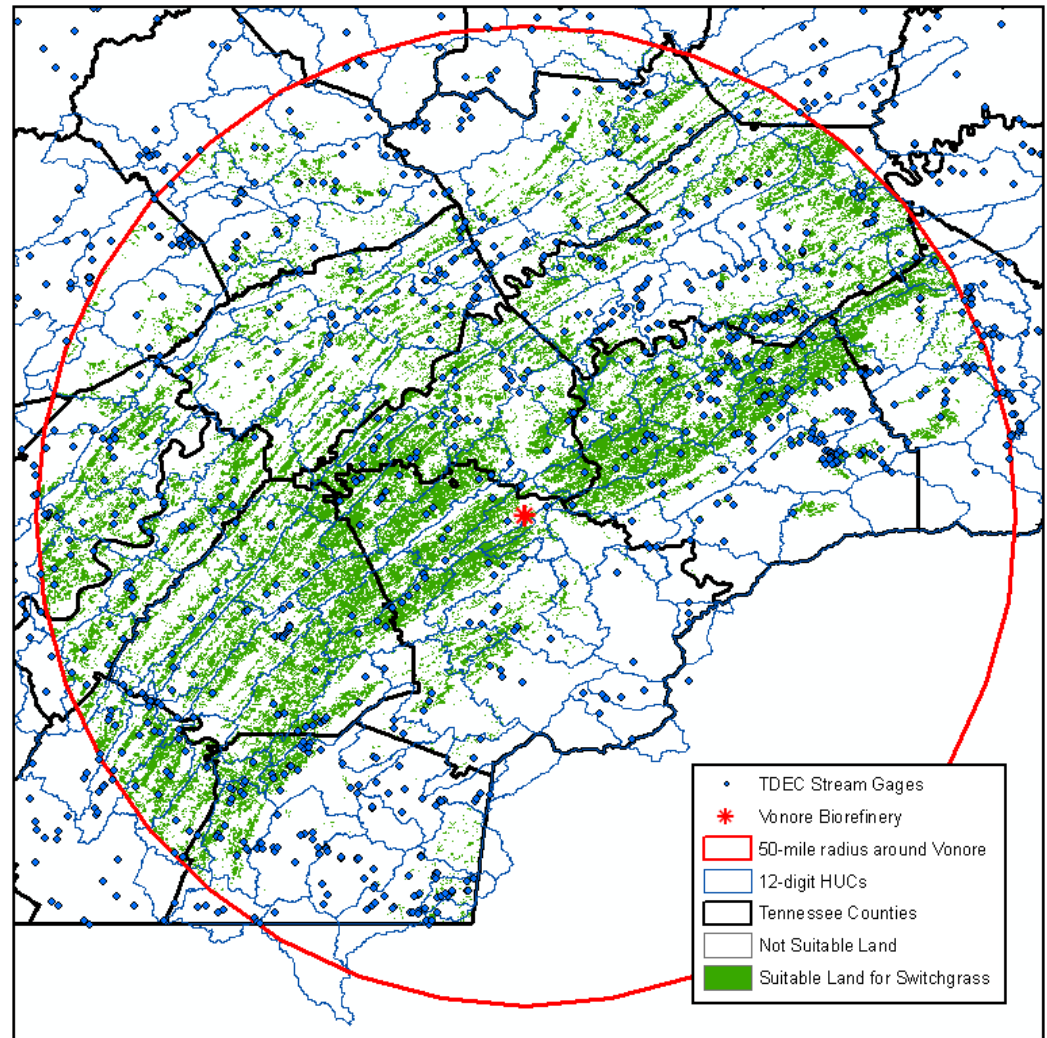
- “Adopting practices and developing products that are environmentally, socially and economically sound, and that can meet present needs without compromising the ability of future generations to meet their needs.”
  - - CSBP Definition

# Soil Carbon Storage



# Watershed Issues and Water Quality

- Working with ORNL Center for Bioenergy Sustainability
- The CBES team has worked with us to
  - to incorporate watershed-based environmental considerations into the SG site-selection process
  - to determine the best locations for obtaining before- and after-water quality & quantity data



# Concluding Remarks

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- Woody residue from harvest and manufacturing operations is today's resource.
- Ultimately, a portfolio of energy crops (ag and forest) will be required to supplement the residue base.
- Work is needed to address the logistics challenges of delivering an engineered feedstock from all systems.
- Sustainability Is Paramount!