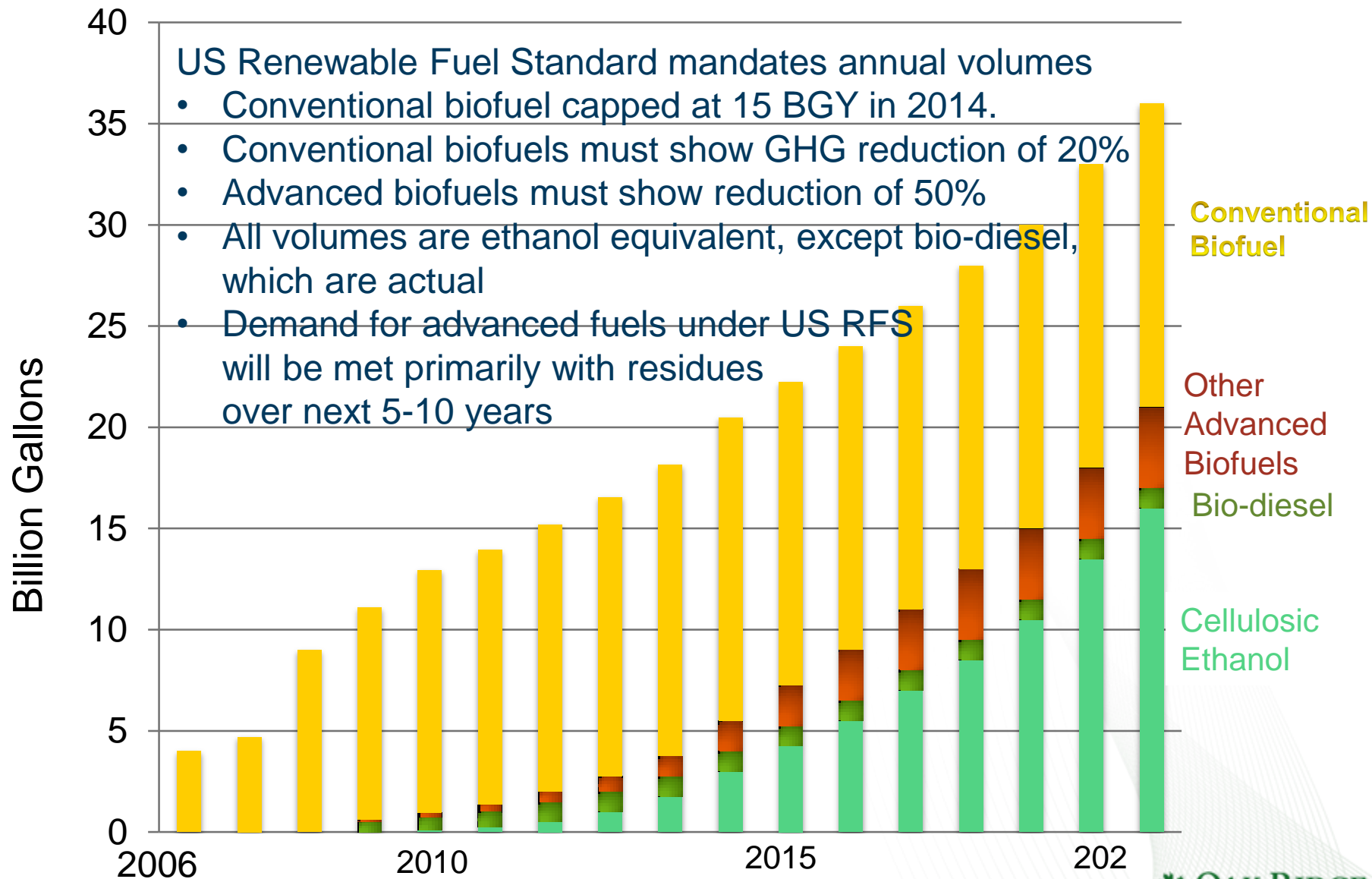


# Where will biomass come from in the future?

## - Depends on laws and regulations

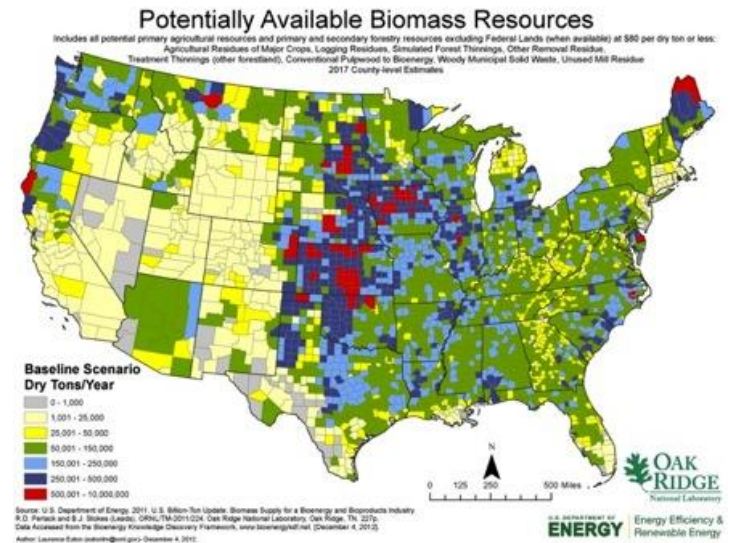


# Biomass for bioenergy: Outline

- What?
- Why?
- Which crops preferable?
- Current sources
- What are future sources?
- **Examples of future sources, assessment**
- Discussion
- Resources for more information

# Future resources: US assessment

- Billion-Ton Study of 2005 helped support US renewable fuel volumes
- Billion Ton Update of 2011 included county-level cost & supply projections
- Conclusion: US has ample feedstock to replace up to 1/3 of petroleum with advanced biofuels
- Feedstock is roughly 1/3 cost of fuel: cost reductions and efficiency in feedstock supply are imperative
- Multi-institutional effort (DOE & USDA)
  - 20-year projections of economic availability of biomass at county level at any year
  - price, location, scenario
- Primary Resources
  - Forest resources (residues)
  - Ag resources (corn stover)
  - Energy crops (switchgrass)



# U.S. Bioenergy supply model Billion Ton Update (USDOE 2011)

- Forecasts of potential biomass
  - POLYSYS partial equilibrium model of US agricultural and forestry sectors.
  - 20-year projections of economic availability of biomass (price, location, scenario)



- Forest resources

- Logging residues
- Forest thinnings (fuel treatments)
- Conventional wood
- Fuelwood
- Primary mill residues
- Secondary mill residues
- Pulping liquors
- Urban wood residues
- [Algae is separate study]

- Agricultural resources

- Crop residues
- Grains to biofuels
- Perennial grasses
- Perennial woody crops
- Animal manures
- Food/feed processing residues
- MSW and landfill gases
- Annual energy crop (added for 2011)

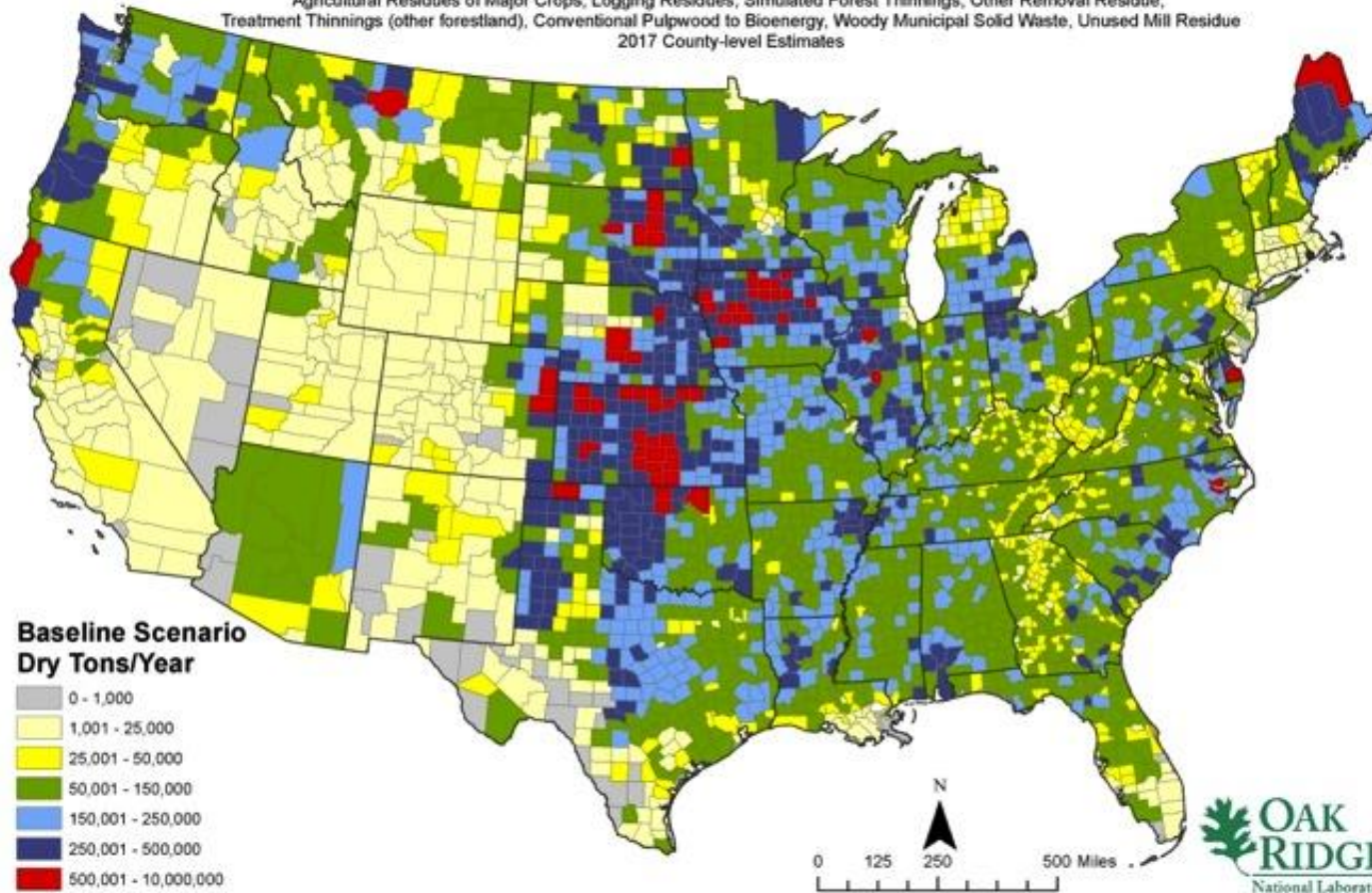


# Example: US county-level Supply Projections

## All feedstocks -- Baseline scenario -- \$60 dry ton<sup>-1</sup>

### Potentially Available Biomass Resources

Includes all potential primary agricultural resources and primary and secondary forestry resources excluding Federal Lands (when available) at \$80 per dry ton or less:  
 Agricultural Residues of Major Crops, Logging Residues, Simulated Forest Thinnings, Other Removal Residue,  
 Treatment Thinnings (other forestland), Conventional Pulpwood to Bioenergy, Woody Municipal Solid Waste, Unused Mill Residue  
 2017 County-level Estimates



Source: 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. Data Accessed from the Bioenergy Knowledge Discovery Framework, [www.bioenergykdf.net](http://www.bioenergykdf.net). [December 4, 2012].  
 Author: Laurence Eaton ([eatoni@ornl.gov](mailto:eatoni@ornl.gov)) - December 4, 2012.

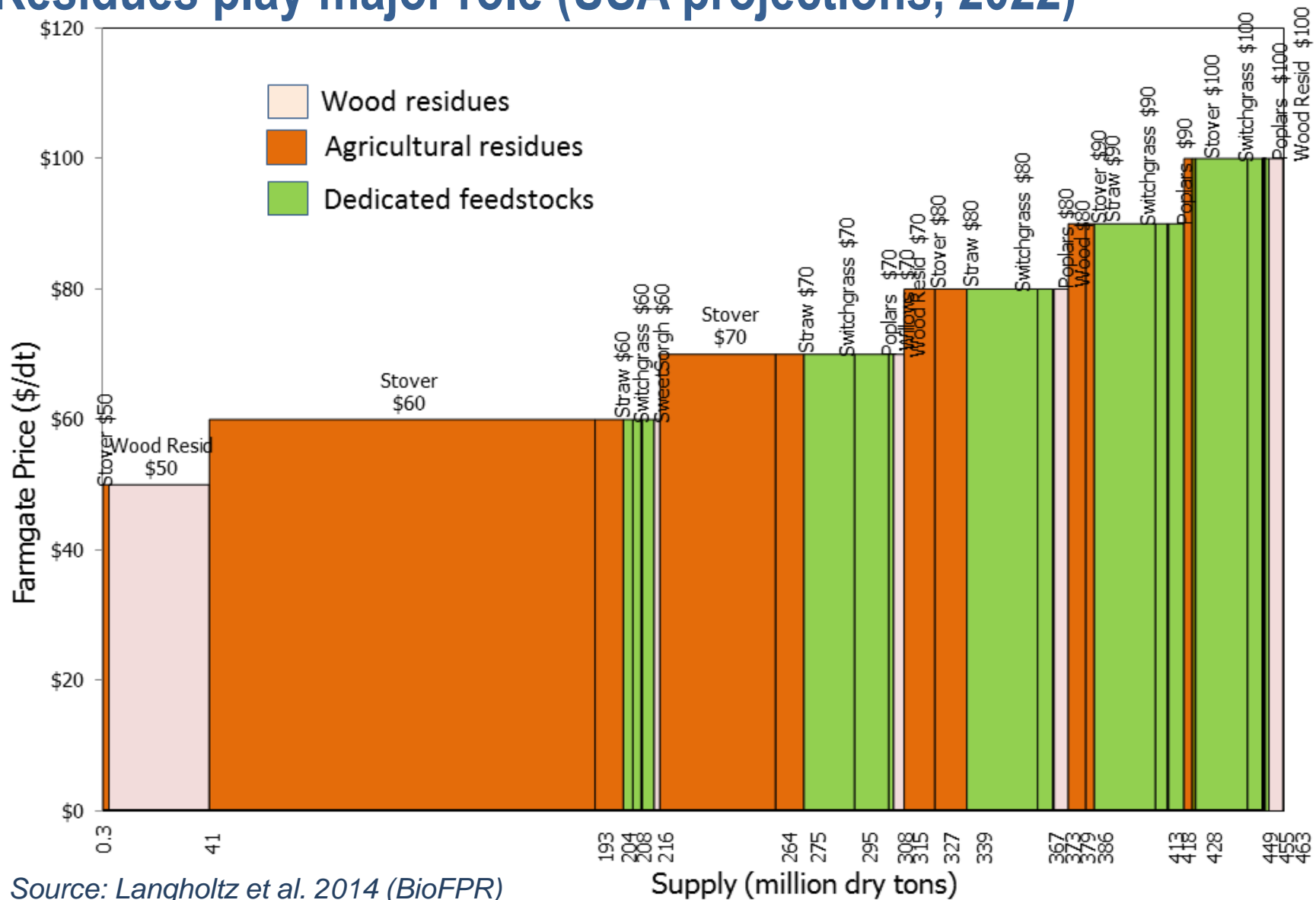
U.S. DEPARTMENT OF  
**ENERGY**

**OAK  
RIDGE**  
National Laboratory

Energy Efficiency &  
Renewable Energy

*155 million DT/yr by 2017 is required to meet EISA targets (85 gal/ton conversion efficiency)*

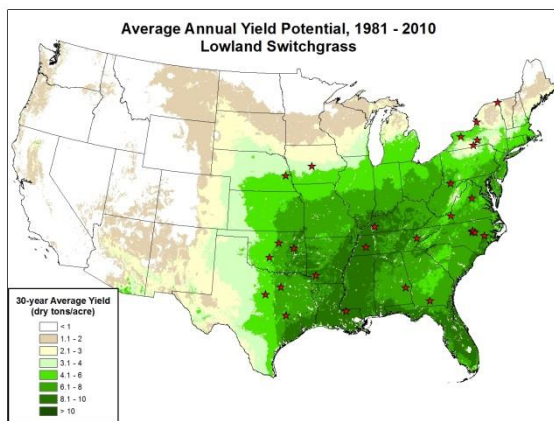
# Future sources depend on supply costs and yields – Residues play major role (USA projections, 2022)



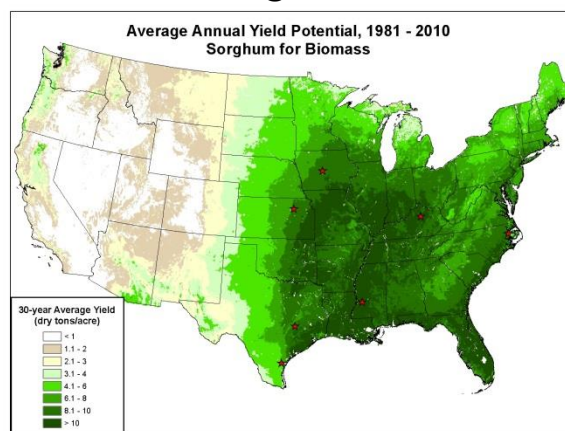
Source: Langholtz et al. 2014 (BioFPR)

# Herbaceous Energy Crops- yield modeling

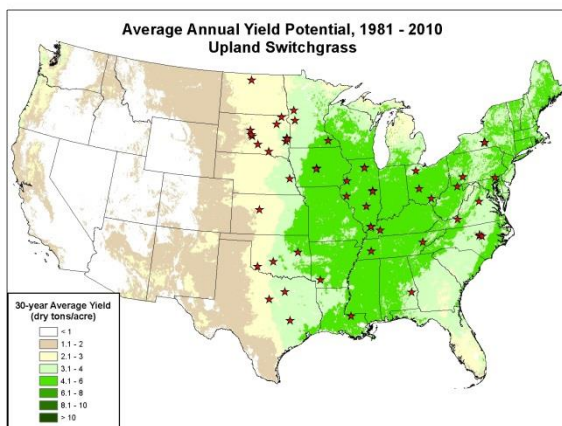
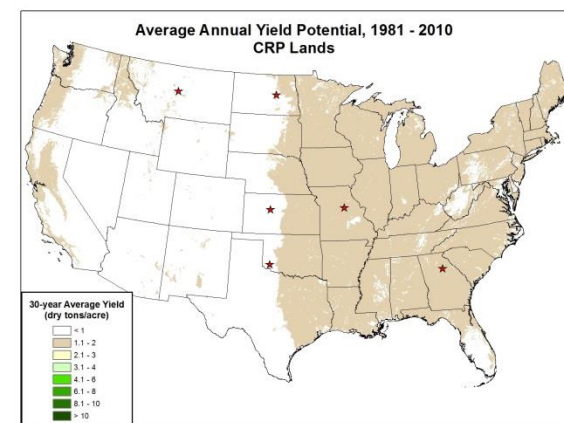
## Lowland Switchgrass



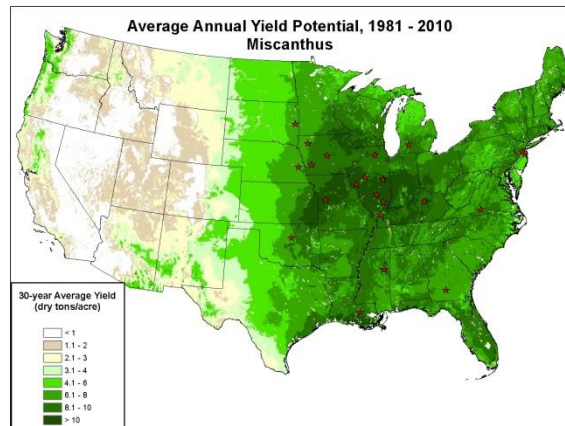
## Sorghum



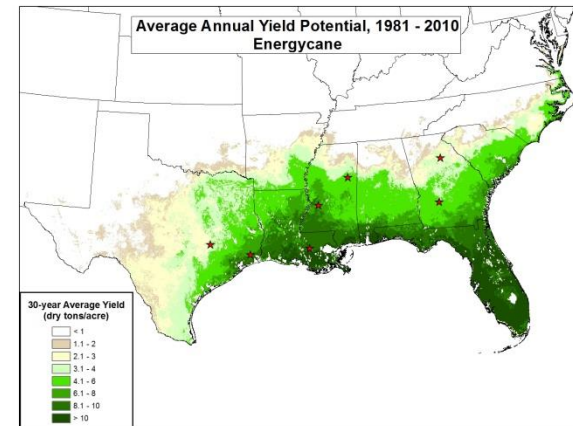
## CRP Grasses



## Upland Switchgrass



## *Miscanthus x giganteus*

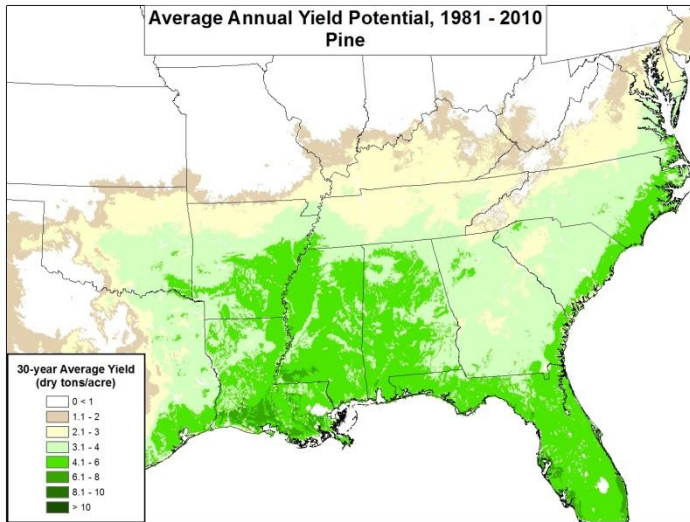


## Energycane

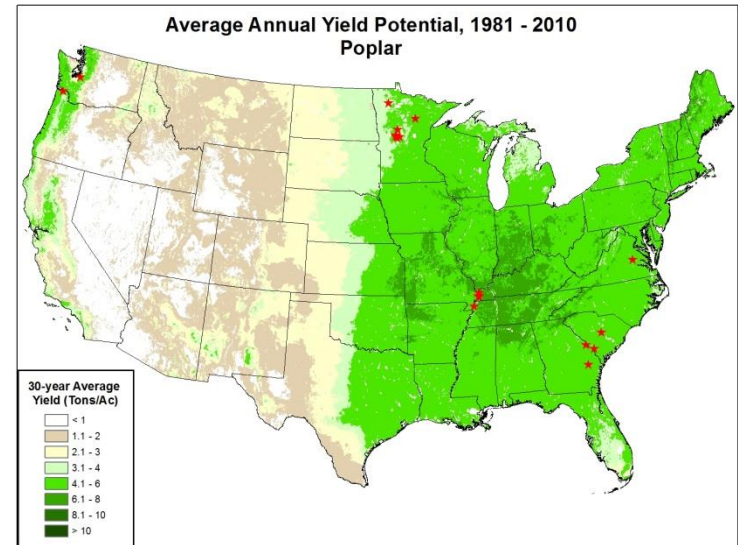


# Woody Energy Crops- yield modeling

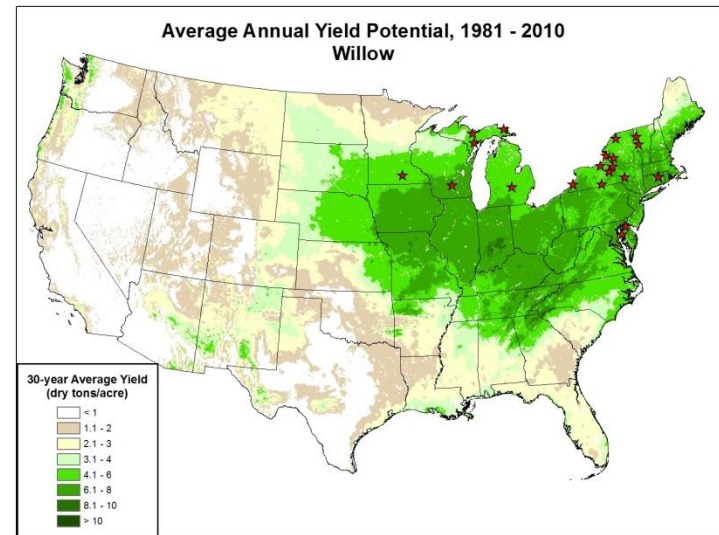
Pine



Poplar



Willow



Plus eucalypts and others...



# Current and future sources: woody and vegetative wastes



## INEOS, Vero Beach, FL

- Expected to produce 8 million gallons per year of cellulosic ethanol and 6 MW of power from wood and vegetative waste
- initiated commercial production of cellulosic ethanol in July 2013
- First commercial production of cellulosic ethanol in the U.S.



# Current and future sources: crop residues (sorghum grits)



## **Myriant Succinic Acid Biorefinery , Lake Providence, LA**

Biochemical conversion of sorghum grits to succinic acid.

Expected to process 50 dry tons/day to produce 30 Million Lbs/year of succinic acid and gypsum



# Current and future sources: corn stover (maize residue) for ethanol

## POET-DSM Project LIBERTY, Emmetsburg, IA

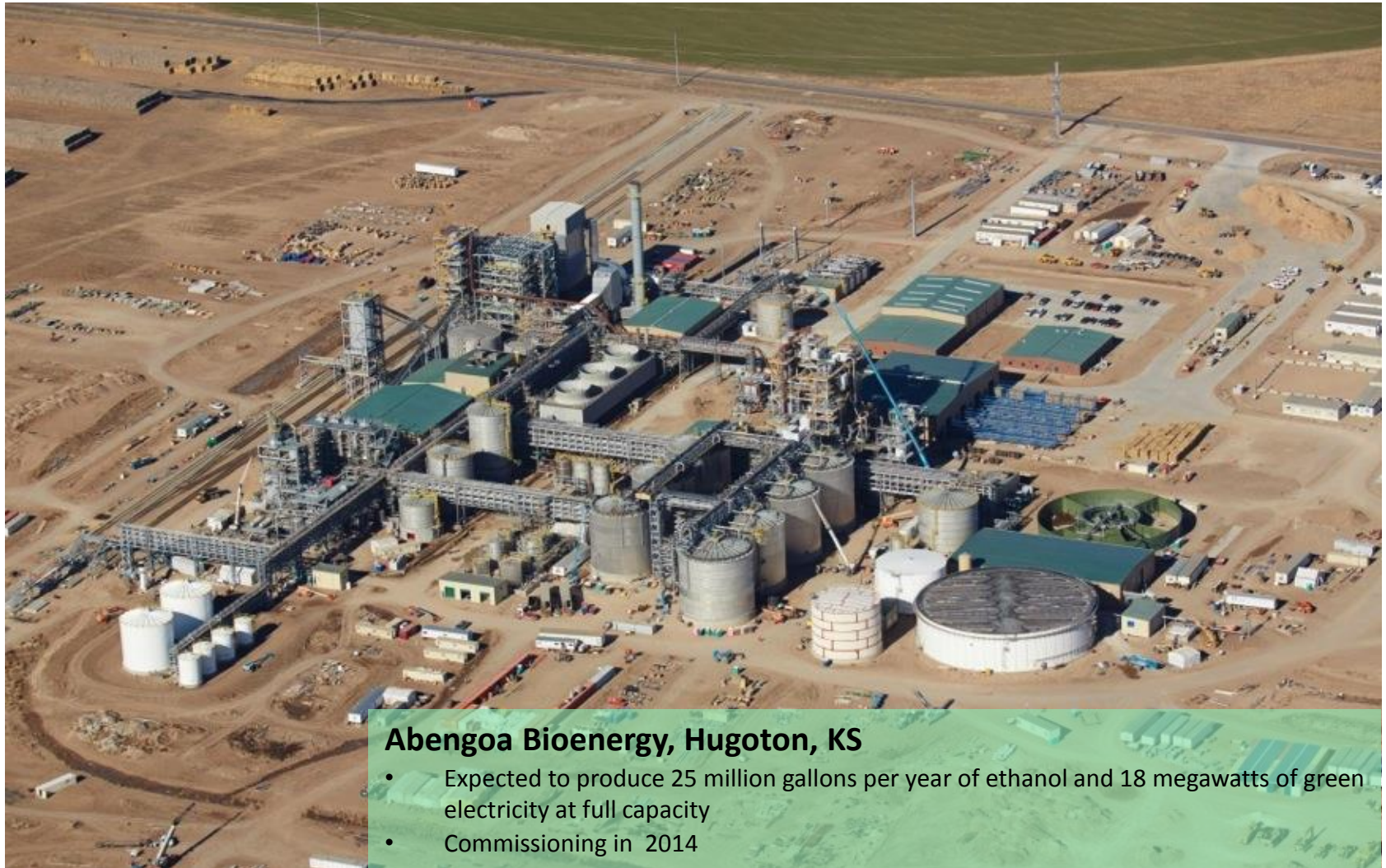
- Expected to produce 20 million gallons per year of cellulosic ethanol at full capacity
- Ribbon cutting 2014



Credit: Jim Spaeth, Bioenergy Technologies Office



# Current and future sources: corn stover (maize residue) for ethanol and electricity



## **Abengoa Bioenergy, Hugoton, KS**

- Expected to produce 25 million gallons per year of ethanol and 18 megawatts of green electricity at full capacity
- Commissioning in 2014

Credit: Jim Spaeth, Bioenergy Technologies Office



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- Future sources?
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- Resources for more information

“You can’t know where you’re headed if you don’t know where you’ve been”

And it helps to understand where you are right now.

“Prediction is very difficult, especially about the future”

-Niels Bohr, Danish physicist.