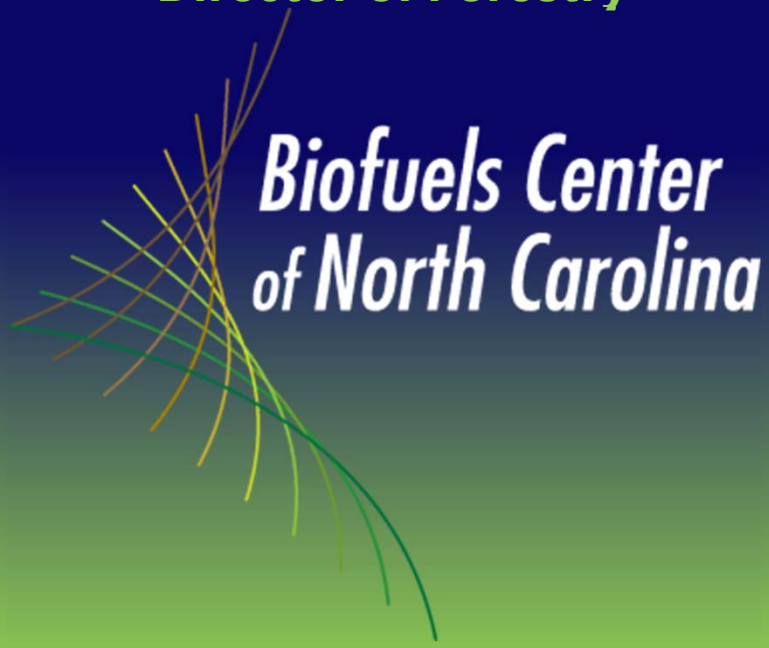
Biofuels – An Answer to a Nursery Manager's Prayer

Dean McCraw
Director of Forestry



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pima magazine CAN DO! club

CAN DO! CLUB

This harvesting crew logs some impressive production figures

In 1980, Union Camp Corp.'s Savannah, Ga., mill began construction of a state-of-the-art boiler to be fired with coal and wood waste.

As part of that project, the firm's Woodlands Division formed a fuel fiber harvesting crew to provide a portion of the fuel for the boiler.

The crew uses conventional logging equipment for felling, skidding and chipping. It works mainly on fee lands, removing unmerchantable standing residual trees left by conventional logging operations.

While this operation is not a new concept, the results achieved are.

In 1985, the crew increased production by 30% and lowered costs by 25% over the preceding year. In the five years the crew has been in operation, production has been hiked by more than 107%.

Last year, the crew established the following production records for the Savannah mill:

- Single-day production of 20 loads.
- Five-day production of 82 loads.
- Five-day delivery of 107 loads.

The Woodlands Division crew that set records at Union Camp's Savannah, Ga., mill are (kneeling, from left) Joe Brunson, Jimmy Haire, Roy Brunson; (standing) Mike Snell, Jimmy Leggett, Sam Smith, Dean McCraw and Ken Sapp. Tommy Leggett is missing from the photo.

- Weekly ton per man-hour rate of 4.59.
- Monthly ton per man-hour rate of 4.13.
- Monthly production of 6,284 tons.
- Annual ton per man-hour rate of 3.49.
- Annual production of 66,247 tons. For those impressive figures, the PIMA tiger tips his Can Do! cap.

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United States consumers use:

140

billion gallons

of gasoline per year

BIOFUELSCENTER.ORG

Source: Energy Information Administration

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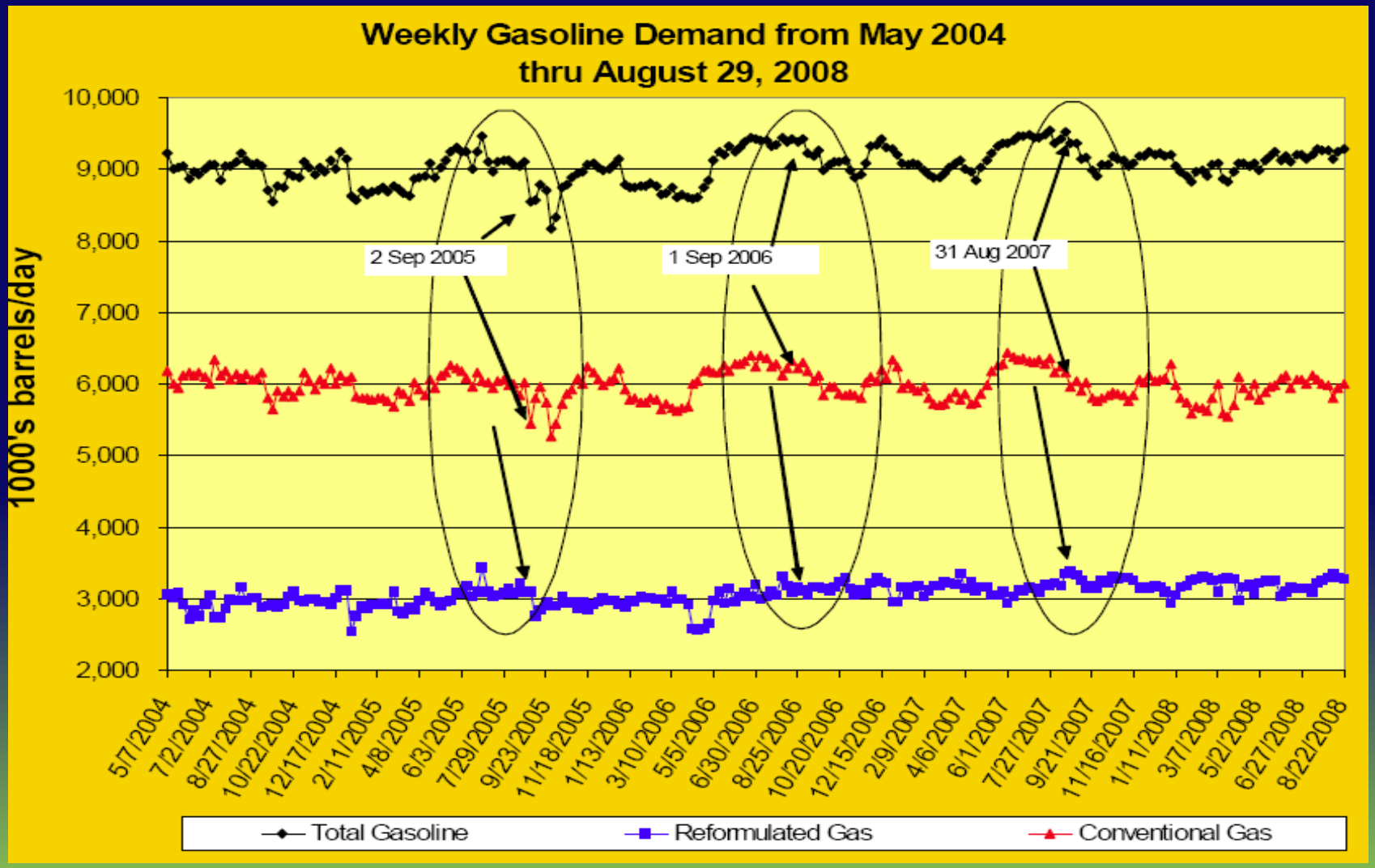
Gasoline Demand US Market: 140 Billion Gallons per Year



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United States consumers use:

45

billion gallons

of diesel fuel per year

BIOFUELSCENTER.ORG

Source: Energy Information Administration

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60%

of all US petroleum products are imported from other countries.

Source: Energy Information Administration

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North Carolina's Strategic Plan for Biofuels Leadership

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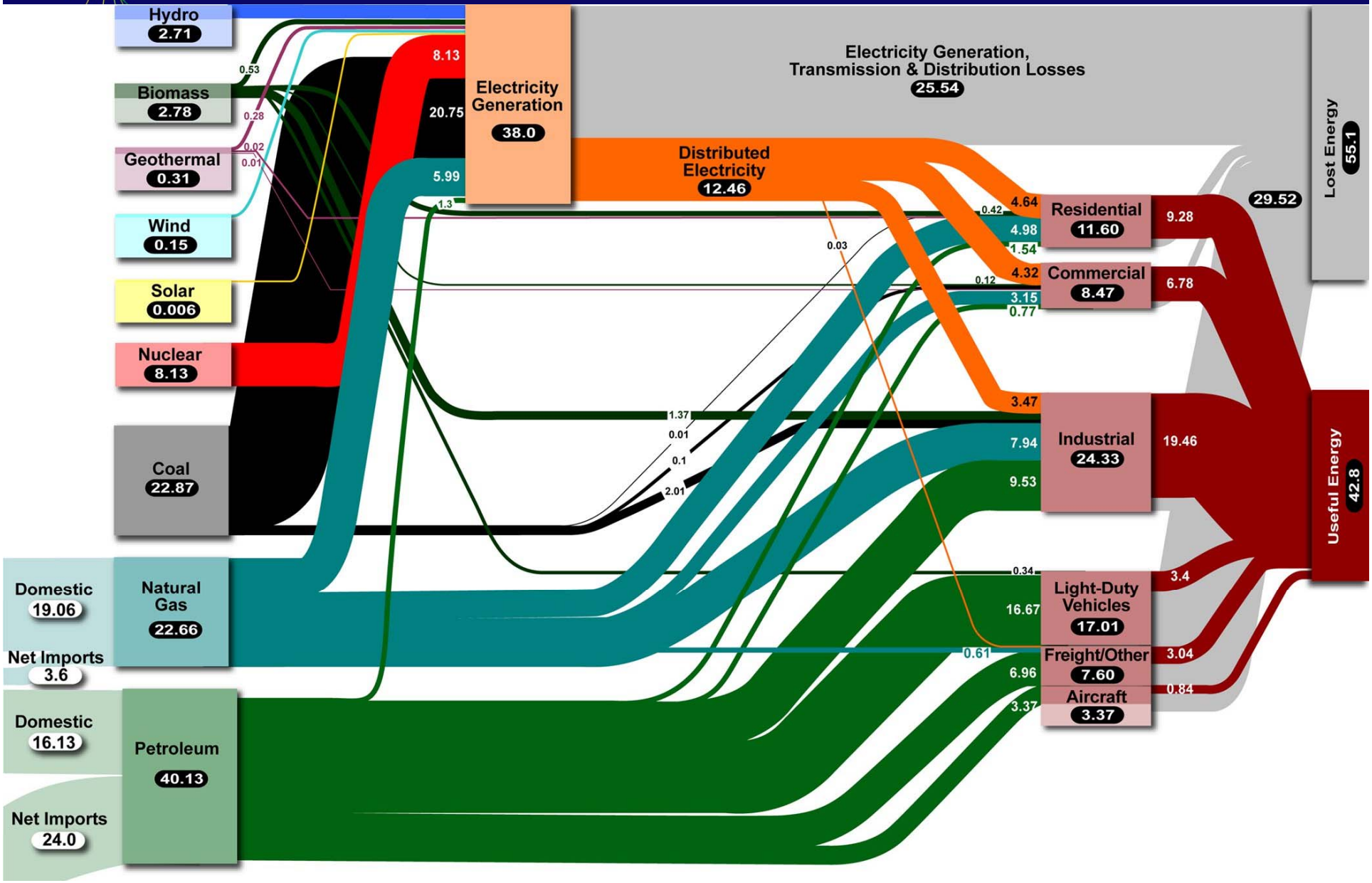
ENERGY FLOWS ARE COMPLEX



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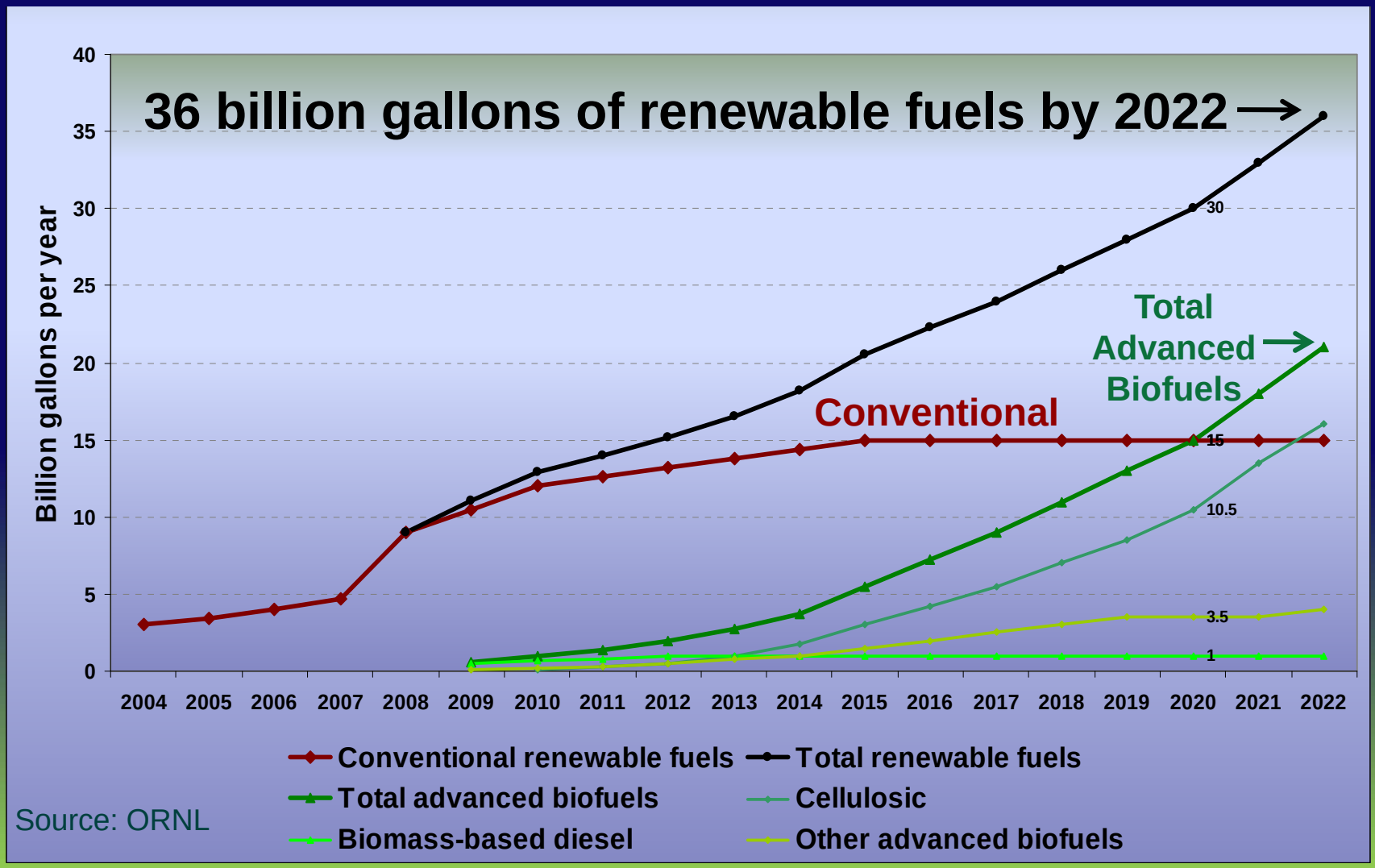
US Energy Bill

(Energy Independence & Security Act 2007)

Production mandate



Source: ORNL

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BIOFUELS 101

BIOFUELSCENTER.ORG

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What is Bioethanol?

- The most widely used biofuel today
- Also known as ethyl alcohol or grain alcohol
- Can be used either as an alternative fuel or as an octane-boosting, pollution-reducing additive to gasoline
- An alcohol fuel made from sugars and starch found in plants

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What is Biodiesel?

- A clean burning alternative fuel
- Produced from domestic, renewable resources such as new and used vegetable oils and animal fats
- Primarily produced through base catalyzed transesterification
- Simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics
- Can be blended at any level with petroleum diesel

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The Ethanol Benchmark

Corn – Considered the "benchmark" in the US

- Nearly all of the ten billion gallons of fuel ethanol produced in the US comes from corn
- In North Carolina, we're looking for alternatives to corn that can grow well in our soils and climate conditions

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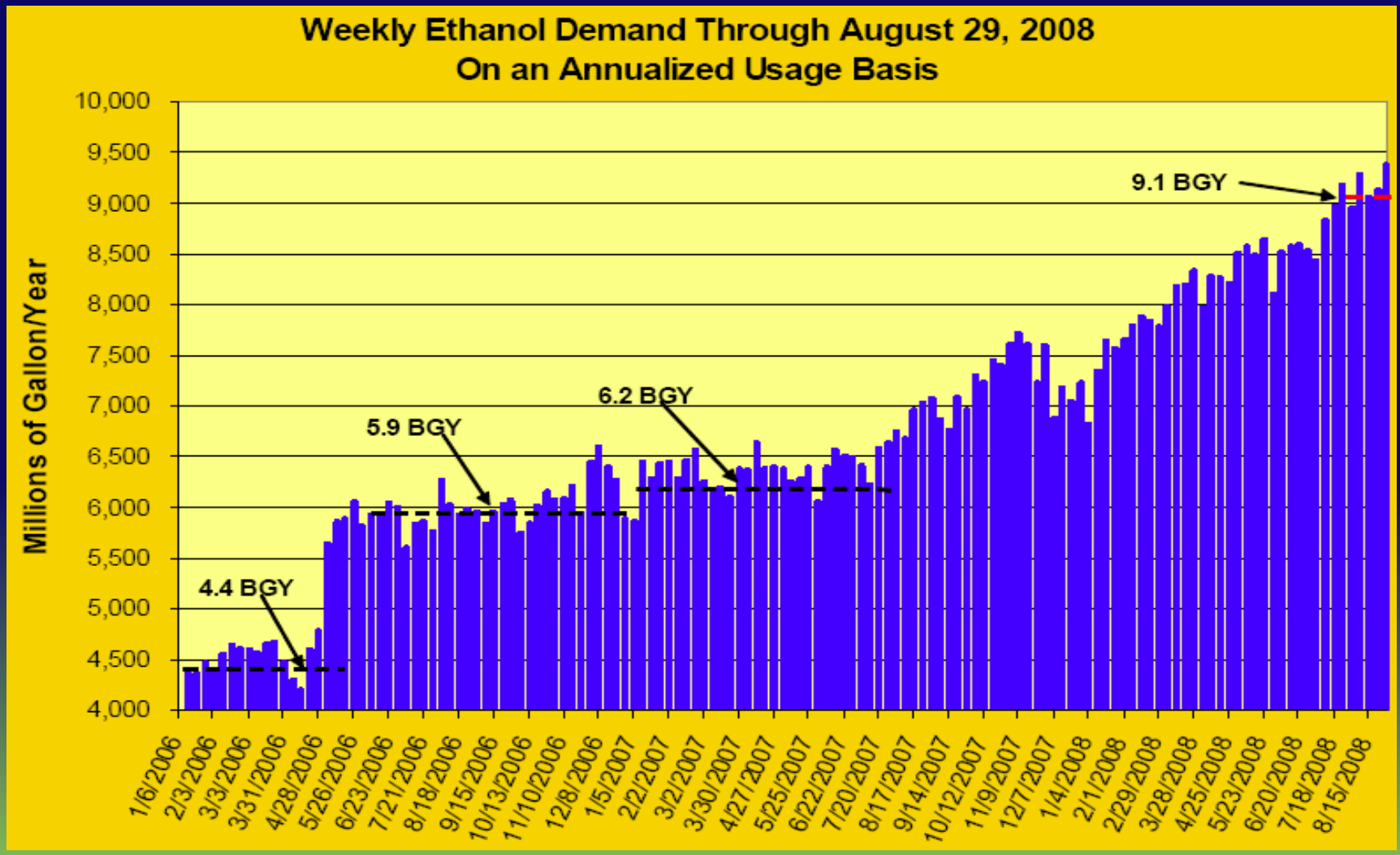
US Fuel Ethanol Consumption



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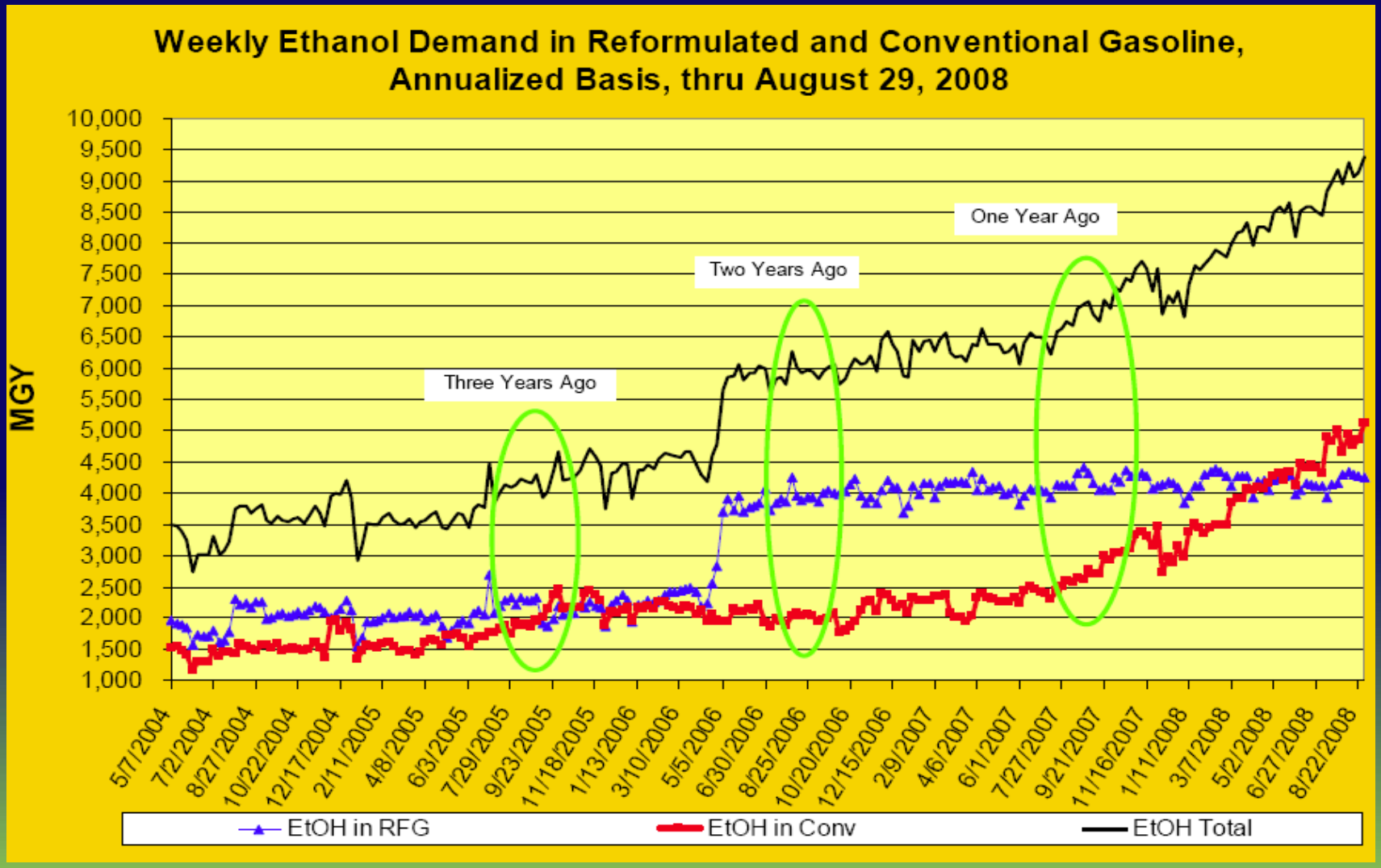
How Fuel Ethanol is Used in the US Market



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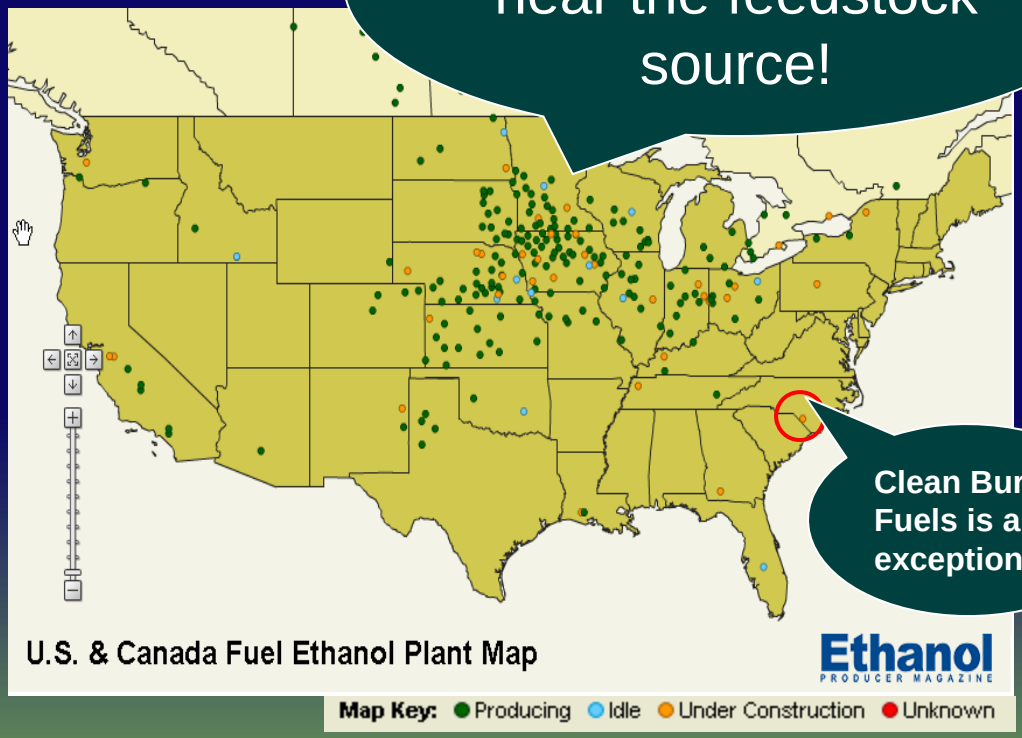
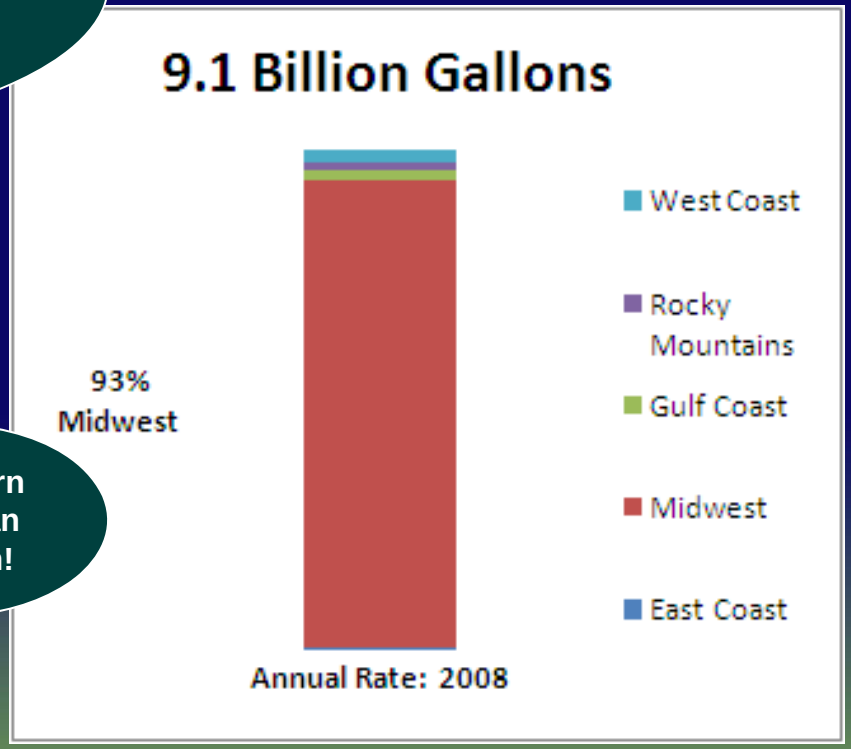
US FUEL ETHANOL PRODUCTION BY REGION

Production is sited near the feedstock source!



Clean Burn Fuels is an exception!



Source: http://www.ethanolproducer.com/plantmap/

http://tonto.eia.doe.gov/dnav/pet/pet_pnp_oxy_a_EPOOXE_YOP_mbbl_m.htm

Energy Information Administration
Official Energy Statistics from the U.S. Government

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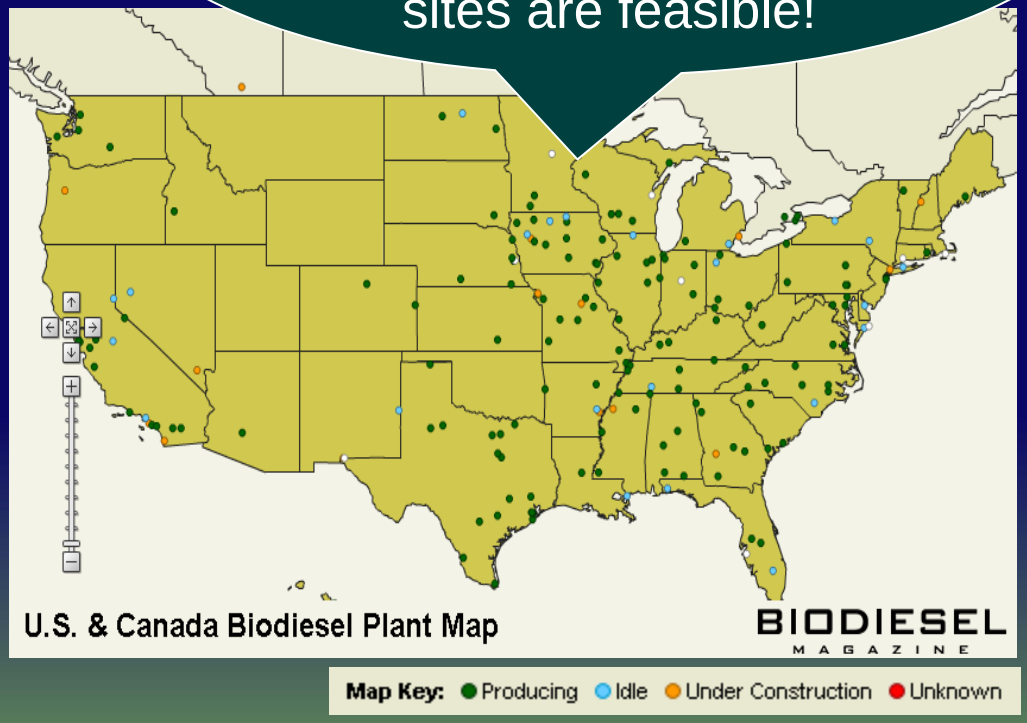
US Biodiesel Production by Region

Production is generally sited at the feedstock source, but port and rail sites are feasible!



Source: http://www.biodieselmagazine.com/plantmap/

Top 10 States

1. Iowa 351.5 Mgy
2. Texas 265 Mgy
3. Illinois 199 Mgy
4. Alabama 155 Mgy
5. New Jersey 134 Mgy
6. Indiana 130 Mgy
7. Washington 116 Mgy
8. Nevada 109 Mgy
9. Missouri 107 Mgy
10. North Dakota 93 Mgy

Oct. 2007 – BBI International

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Feedstocks for Biofuels

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Feedstock Terms

- Generation 1 – Technology available today
- Generation 1.5 – Promising technologies under development
- Generation 2.0 – Technologies needing further development

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Potential Crops for Cellulosic Ethanol or Green Gasoline

Woody biomass (trees)

Switchgrass

Miscanthus

High biomass sorghum

Crop residues

- Barley
- Corn stover
- Wheat
- Oats

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Potential Crops for Biodiesel

- Soybeans – “benchmark”
- Waste vegetable oil
- Rendered animal fat
- Canola/rape seed
- Peanuts

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Biofuels Feedstock Development Plots

- Introduce biofuels crops to the forestry/farming community
- Analyze crop performance at several locations
  - Gather data
  - Tillage
  - Soil types
- Explore harvesting techniques

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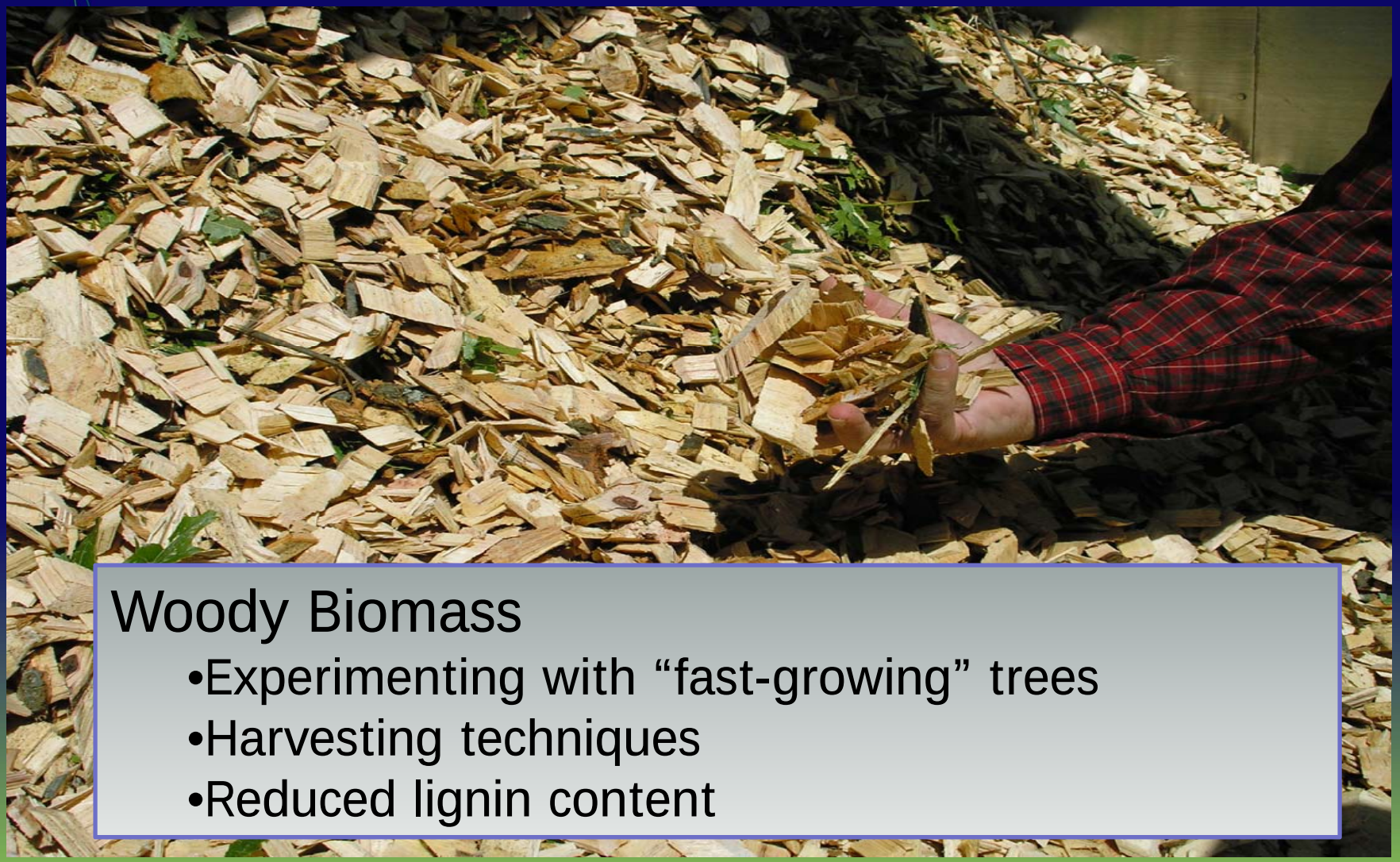
Generation 2.0
Cellulosic Energy Crops



Woody Biomass

- Experimenting with “fast-growing” trees
- Harvesting techniques
- Reduced lignin content

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FOREST RESIDUE HOLDS ONE OF THE LARGEST POTENTIALS FOR BIOFUELS DEVELOPMENT

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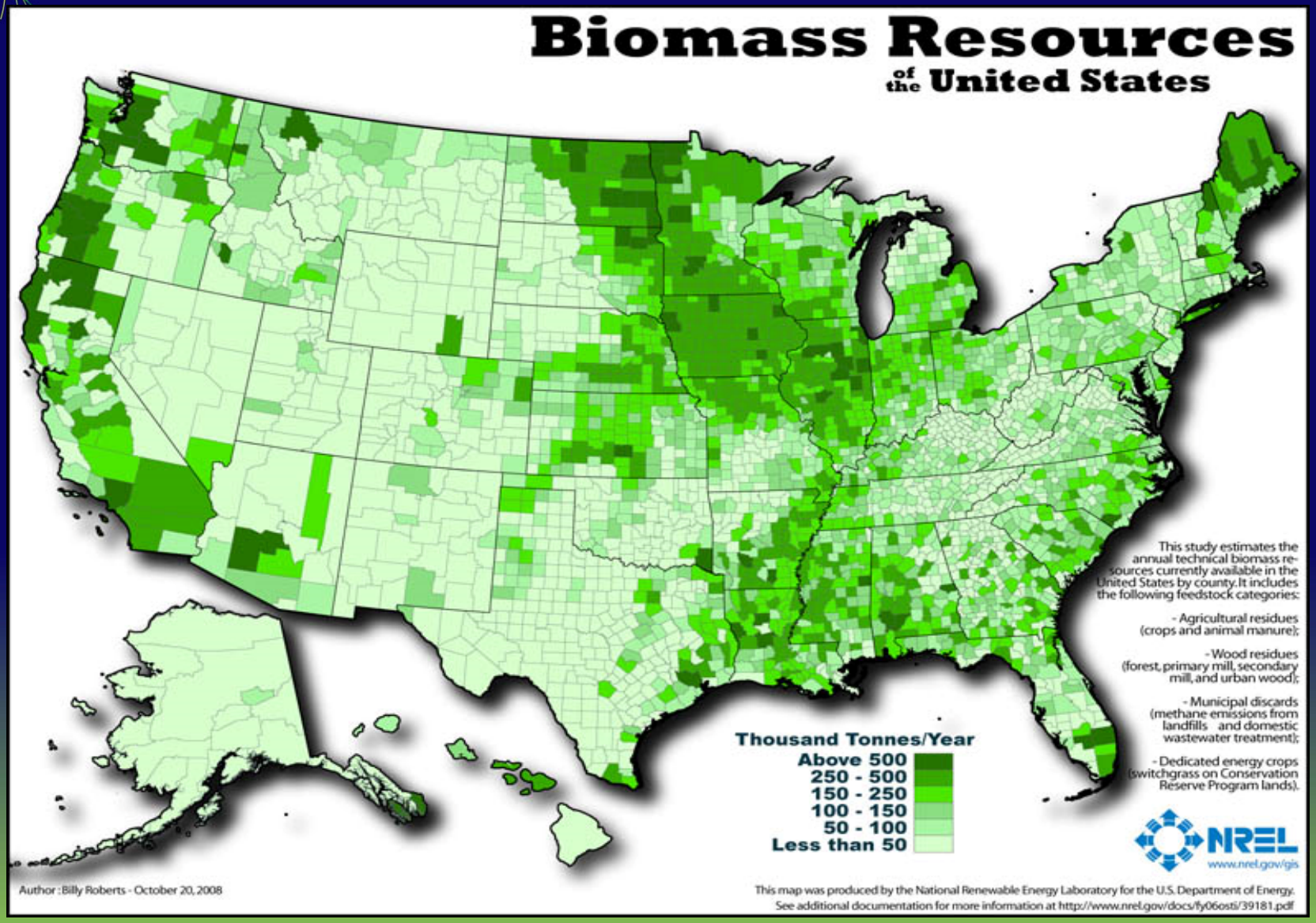

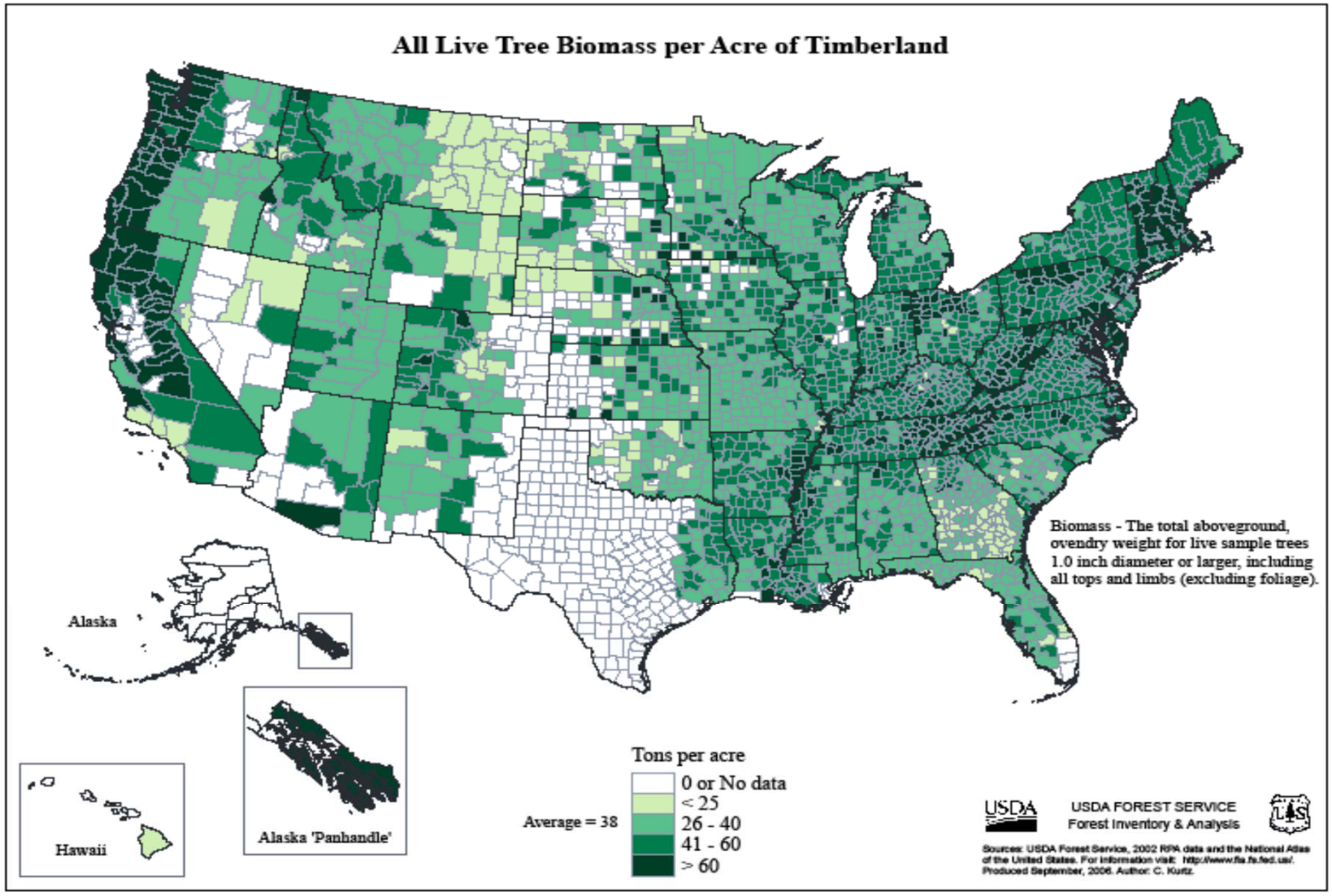
All Live Tree Biomass per Acre of Timberland
Biomass - The total aboveground, ovendry weight for live sample trees 1.0 inch diameter or larger, including all tops and limbs (excluding foliage).
Alaska
Hawaii
Alaska 'Panhandle'
Tons per acre
Average = 38
0 or No data
< 25
26 - 40
41 - 60
> 60
USDA
USDA FOREST SERVICE
Forest Inventory & Analysis
Sources: USDA Forest Service, 2002 RPA data and the National Atlas of the United States. For information visit: http://www.fia.fs.fed.us/.
Produced September, 2006. Author: C. Kurtz.

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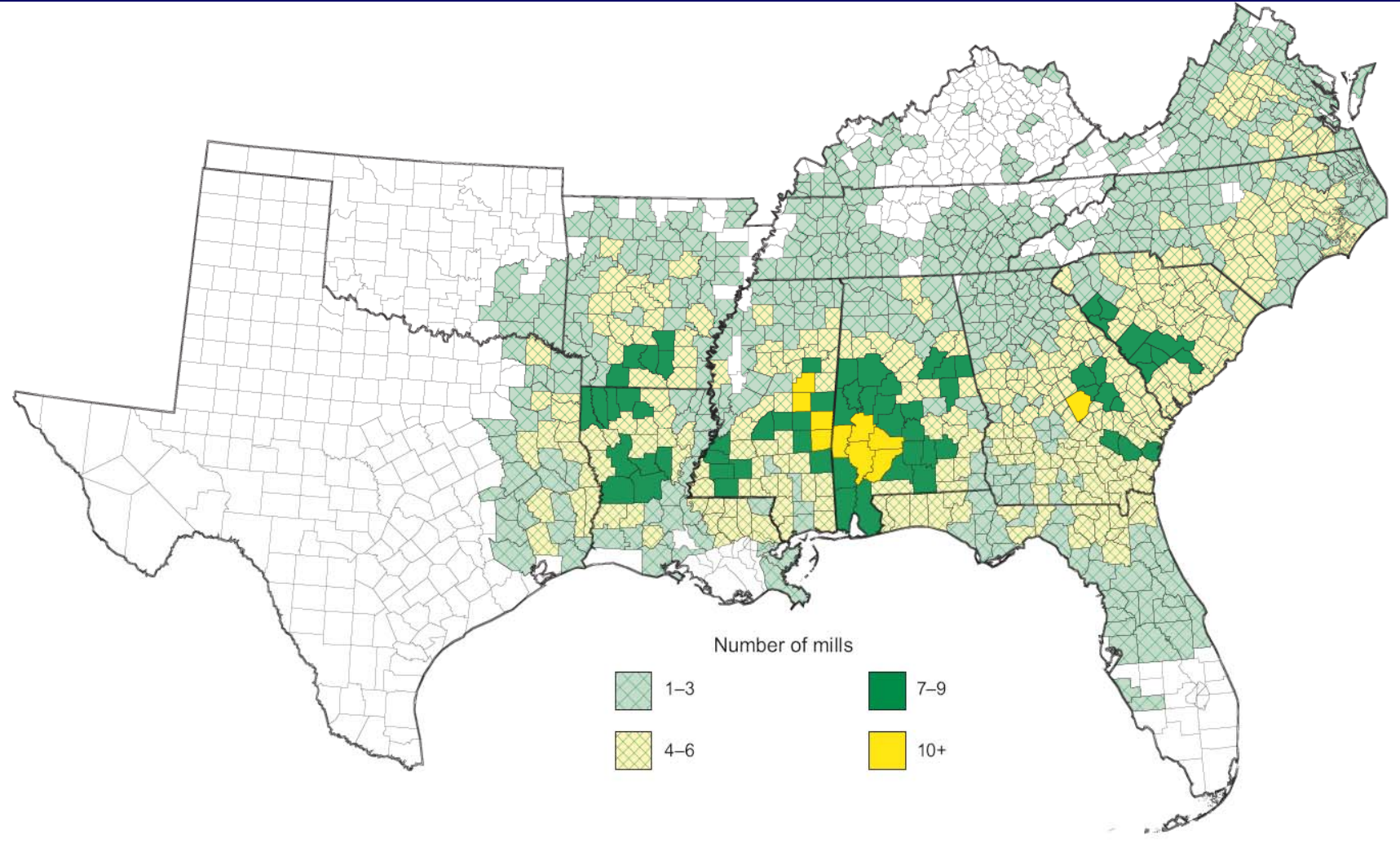
Number of mills competing for softwood roundwood by county or parish, 2007



Southern Pulpwood Production, 2007, USFS Southern Research Station, April 2009

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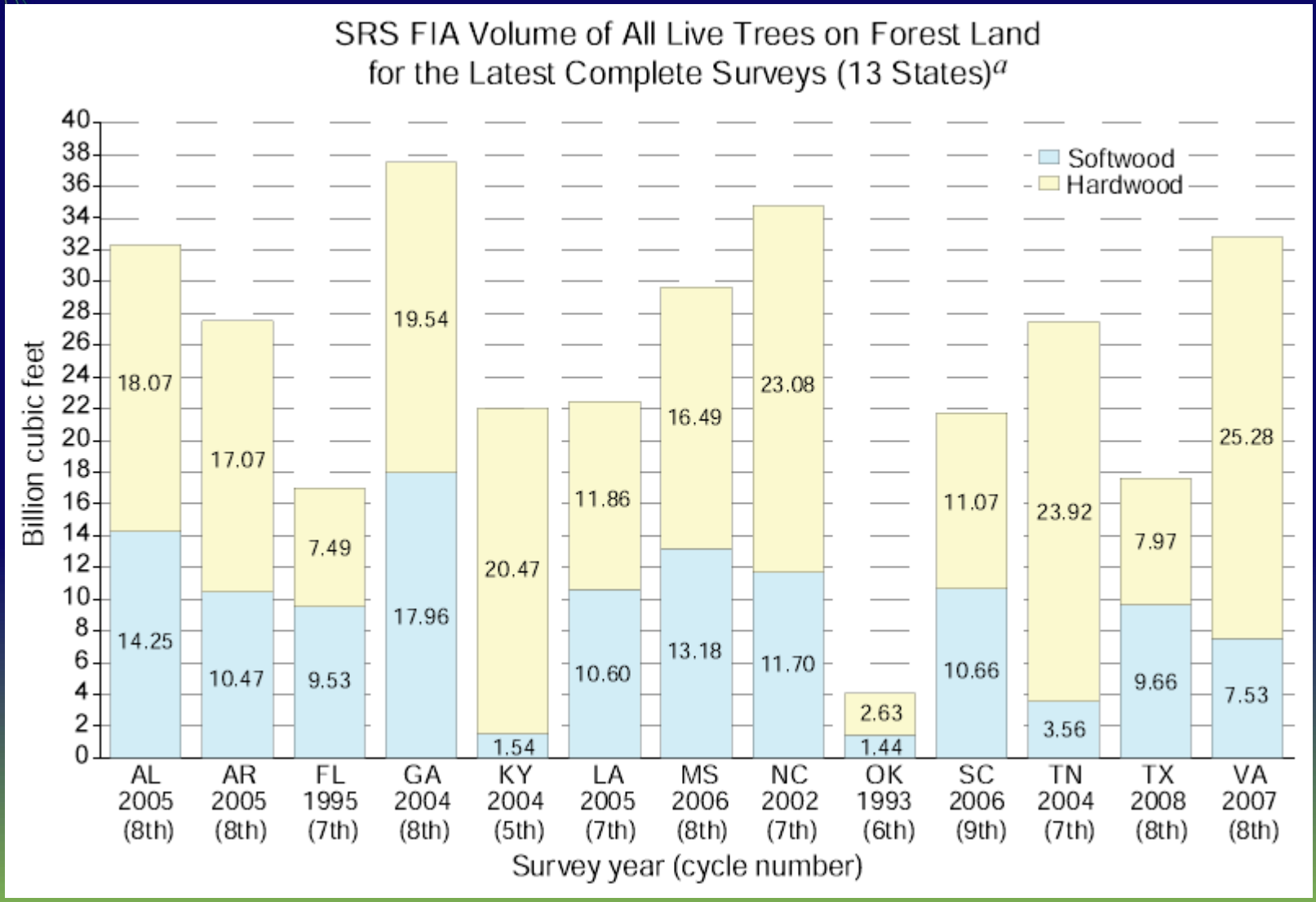

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Building Cellulosic Ethanol

U.S. and Canada Cellulosic Ethanol Plants - Operating, Planned, or Under Construction

Under Construction or Planned:

1. **Abengoa Bioenergy** | Hugoton, KS
   Capacity: 13-15 mmgy | **Feedstock:** Various sources | **Plant type:** Commercial
2. **AE Biofuels** | Butte, MT | **Feedstock:** Multiple sources
   Plant type: Small-scale commercial
3. **Alltech** | Springfield, KY | **Capacity:** 10 mmgy | **Feedstock:** Multiple sources
   Plant type: Small-scale commercial | **Production start:** Late 2009
4. **Agresti Biofuels** | Pike County, KY | **Capacity:** 20 mmgy
   Feedstock: Municipal waste | **Plant type:** Commercial | **Production start:** 2010
5. **BlueFire Ethanol, Inc.** | Southern CA | **Capacity** 17.5 mmgy
   Feedstock: Municipal waste | **Plant type:** Commerical
6. **BlueFire Ethanol, Inc.** | Lancaster, CA | **Capacity:** 3.1 mmgy
   Feedstock: Municipal waste | **Plant type:** Commerical
7. **Catalyst Renewables Corp** | Lyonsdale, NY
   Capacity: N/A | **Feedstock:** Woodchips
8. **Clemson University Restoration Institute** | North Charleston, SC
   Feedstock: Multiple sources | **Plant type:** Pilot | **Production Start:** 2011
9. **Coskata** | Madison, PA | **Capacity:** 10,000 gpy
   Feedstock: Multiple sources | **Plant type:** Pilot
10. **DuPont Danisco Cellulosic Ethanol, LLC** | Vonore, TN | **Capacity:** 250,000 gpy
    Feedstock: Multiple sources | **Plant type:** Pilot
11. **Ecofin, LLC** | Washington, KY | **Capacity:** 1.3 mmgy
    Feedstock: Corn cobs | **Plant type:** Commercial
12. **Flambeau River Biofuels, LLC** | Park Falls, WI
    Capacity: 6 mmgy | **Feedstock:** Wood waste | **Plant type:** Commercial
13. **Greenfield Ethanol** | Edmonton, AB | **Capacity:** 36 million liters py
    Feedstock: Municipal waste | **Plant type:** Commercial | **Production start:** 2010
14. **Gulf Coast Energy** | Mossy Head, FL
    Capacity: 20 mmgy | **Feedstock:** Wood waste | **Plant type:** Commercial
15. **ICM, Inc.** | St. Joseph, MO | **Capacity:** 1.5 mmgy
    Feedstock: Switchgrass, sorghum, stover, forage | **Plant type:** Commercial
16. **Iogen Corp.** | Birch Hills, SK | **Capacity:** 20 mmgy
    Feedstock: Wheat, barley straw | **Plant type:** Commercial
17. **Lignol Innovations, Inc.** | Commerce City, CO
    Capacity: 2 mmgy | **Feedstock:** Wood | **Plant type:** Pilot
18. **Mascoma Corp.** | Upper Michigan Penn. | **Production Start:** 2012
    Capacity: 40 mmgy | **Feedstock:** Wood | **Plant type:** Commercial
19. **Mascoma Corp.** | Rome, NY | **Production Start:** 2nd Quarter 2009
    Capacity: 500,000 gpy | **Feedstock:** Multiple sources | **Plant type:** Pilot
20. **NewPage Corp.** | Wisconsin Rapids, WI | **Capacity:** 5.5 mmgy
    Feedstock: Woody biomass, mill residue | **Plant type:** Commercial
21. **New Planet Energy Florida LLC** | Indian River County, FL
    Feedstock: Multiple including MSW | **Plant type:** Commercial
22. **Pacific Ethanol** | Boardman, OR
    Capacity: 2.7 mmgy | **Feedstock:** Mixed biomass | **Plant type:** Demonstraton
23. **Pan Gen Global** | Stuttgart, AR | **Capacity:** 12.5 mmgy
    Feedstock: Rice hulls | **Plant type:** Commercial | **Production start:** 4th quarter, 20 0
24. **POET-Project Liberty** | Emmetsburg, A | **Capacity:** 25 mmgy
    Feedstock: Corn cobs, fiber | **Plant type:** Commercial | **Production start:** 2011
25. **Pure Vision Technology** | Ft. Lupton, CO | **Production start:** 3rd quarter, 2010
    Capacity: 2 mmgy | **Feedstock:** Corn stalks and grasses | **Plant type:** Pilot
26. **Range Fuels** | Treutlen County, GA
    Capacity: 20 mmgy | **Feedstock:** Wood waste | **Plant type:** Commercia
27. **RSE Pulp & Chemical** | Old Town, ME | **Production start:** 2010
    Capacity: 2.5 mmgy | **Feedstock:** Wood extract | **Plant type:** Demonstration
28. **SunOpta Bioprocess LLC/Central Minnesota Ethanol Co-op** | Little Falls, MN
    Capacity: 10 mmgy | **Feedstock:** Wood chips | **Plant type:** Commercial
29. **Xethanol Corp./Southeast Biofuels** | Auburndale, FL
    Capacity: 8 MMGY | **Feedstock:** Citrus peels | **Plant type:** Commercial
30. **ZeaChem** | Boardman, OR | **Capacity:** 1.5 mmgy
    Feedstock: Poplar trees, sugar, wood chips | **Plant type:** Commercial

In Operation:

31. **Abengoa Bioenergy** | York, NE | **Plant type:** Pilot
    Capacity: 200,000 gpy | **Feedstock:** Various | **Production slated:** September 2007
32. **AE Biofuels** | Butte, MT | **Capacity:** 150,000 gpy | **Feedstock:** Multiple sources
    Plant type: Demonstration | **Production started:** August 2008
33. **POET-Project Bell** | Scotland, SD | **Capacity:** 20,000 gpy
    Feedstock: Corn cobs, fiber | **Plant type:** Pilot | **Production start:** 4th quarter, 2008
34. **Verenium Corp.** | Jennings, LA | **Capacity:** 1.4 mmgy
    Feedstock: Bagasse | **Plant type:** Demonstration | **Production started:** April 2008
35. **Western Biomass Energy (KL Process)** | Upton, WY | **Capacity:** 1.5 mmgy
    Feedstock: Wood waste | **Plant type:** Commercial | **Production started:** Jan. 29, 2008
36. **West Biofuels** | San Rafael, CA | **Capacity:** 1.5 mmgy
    Feedstock: Urban waste | **Plant type:** Pilot | **Production start:** August 2008

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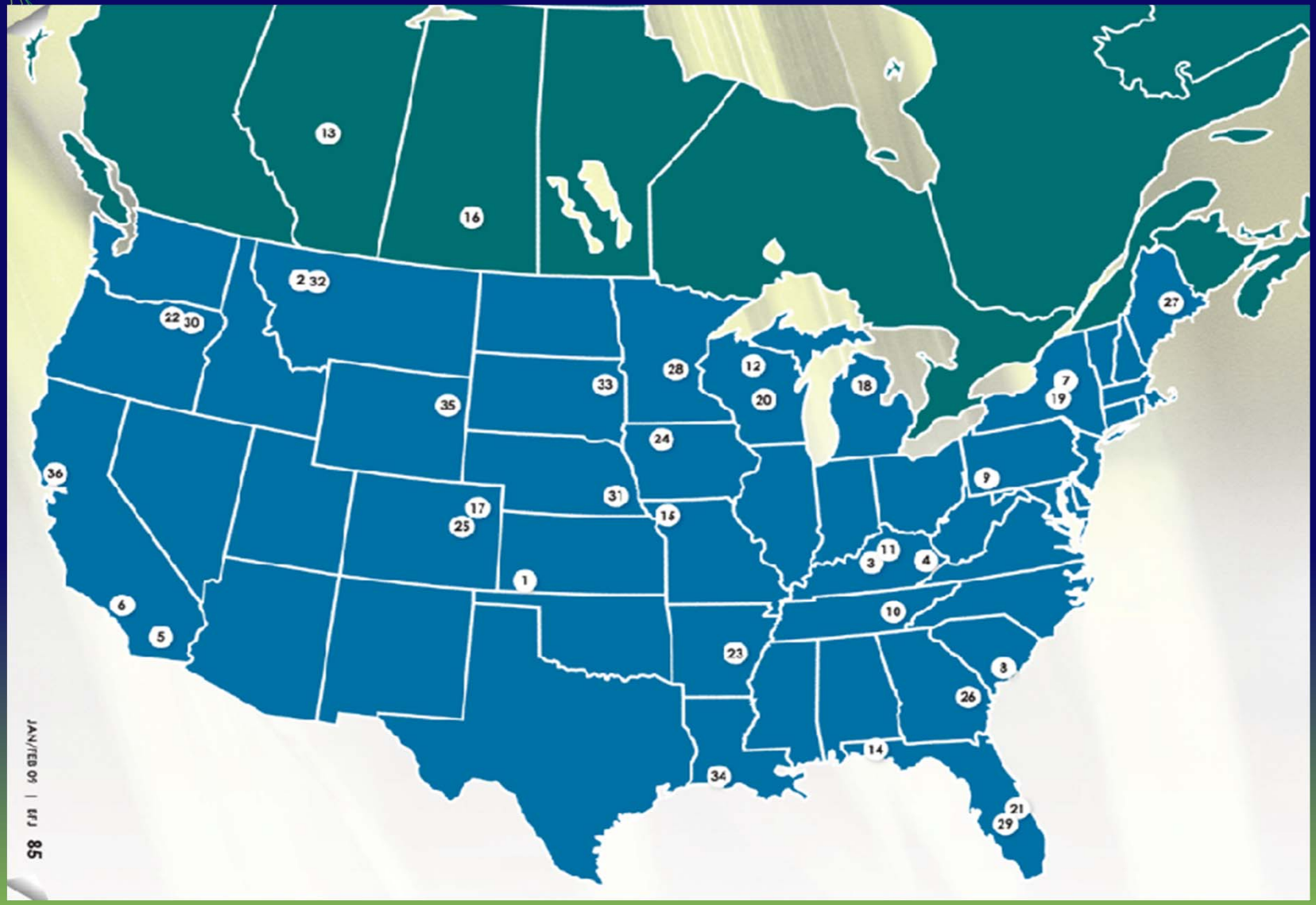
Announced 2nd Generation Biofuels Plants



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Technical Barrier Areas Biochemical Ethanol

- Feedstock Variation
- Feedstock Quality
- Feedstock Cost

Enzyme Production

- Enzyme Cost

Ethanol (Butanol) Recovery

Pretreatment → Conditioning → Enzymatic Hydrolysis → Co-fermentation of C5 & C6 Sugars → Product Recovery → **Products**

- Xylose Yield
- Xylose Degradation
- Solids Loading
- Reactor Costs

- Sugar Losses

- Glucose Yield
- Solids Loading (titer)

- Ethanol Yields
- Ethanol Concentration
- Rate
- Hydrolyzate Toxicity

Residue Processing → **By-products**

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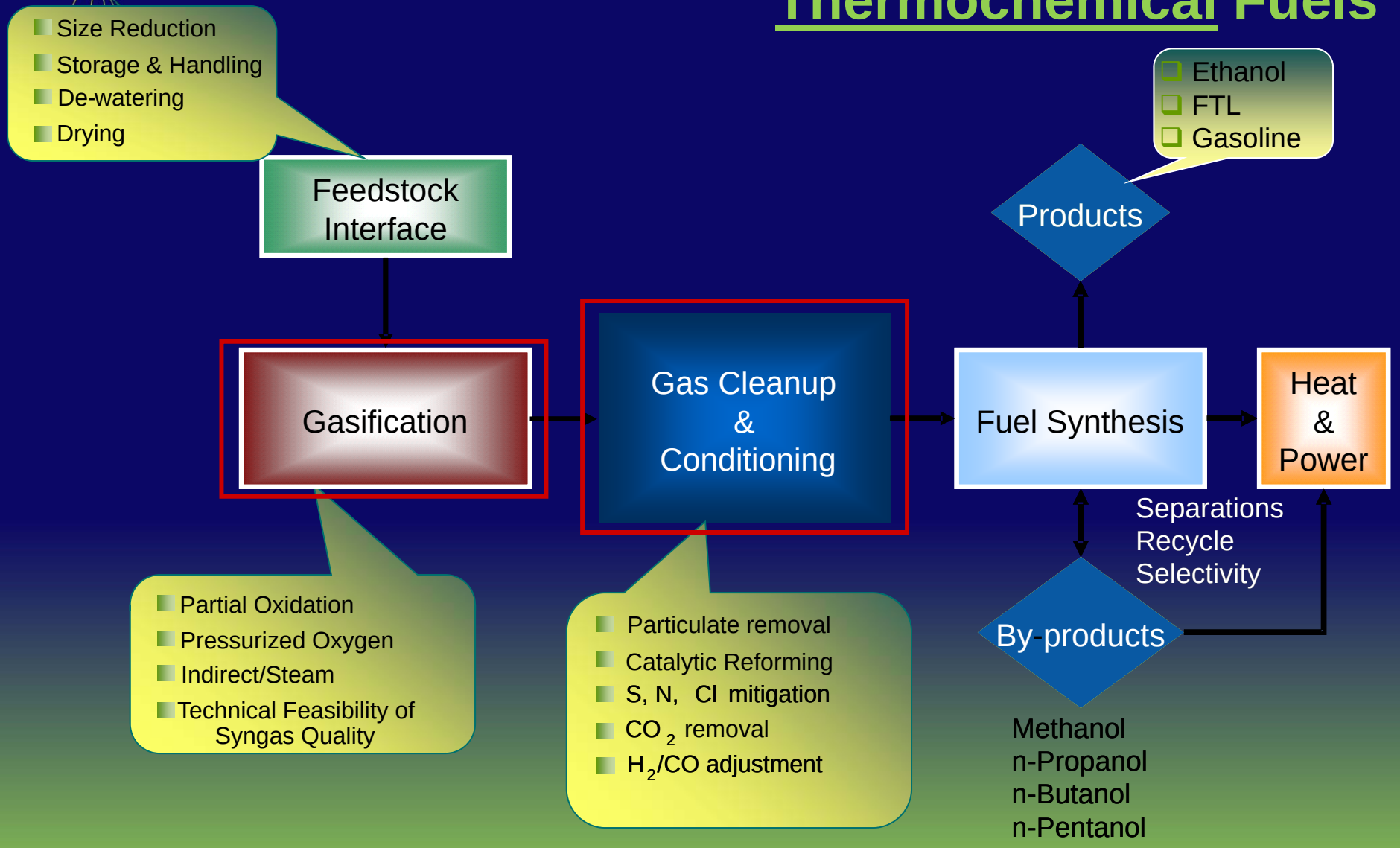
Technical Barrier Areas
Thermochemical Fuels



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EVERYONE IS WORKING ON BIOFUELS

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Needs for the Future

How can the yield of biofuels per acre be increased?

- Increase the yield of biomass feedstock per acre through continued improvement in productivity using advanced breeding, testing and selection methods combined with improved silvicultural techniques
- Increase the yield of biofuel per green ton of biomass by identifying and exploiting genetic variation in wood properties that affect processing characteristics to identify trees with higher conversion efficiencies

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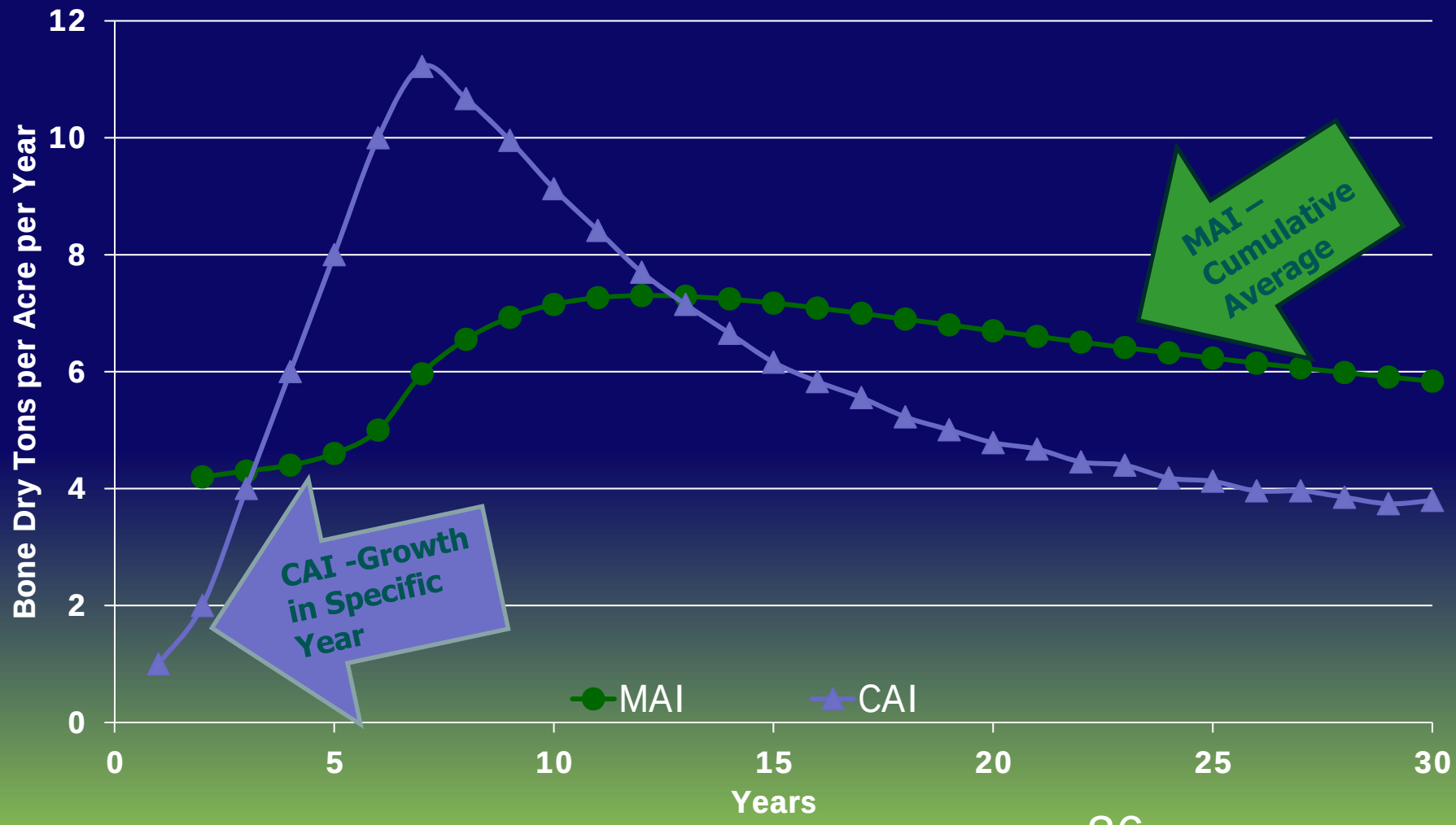
GROWTH PATTERN, SI 85 – 1000 TREES/ACRE



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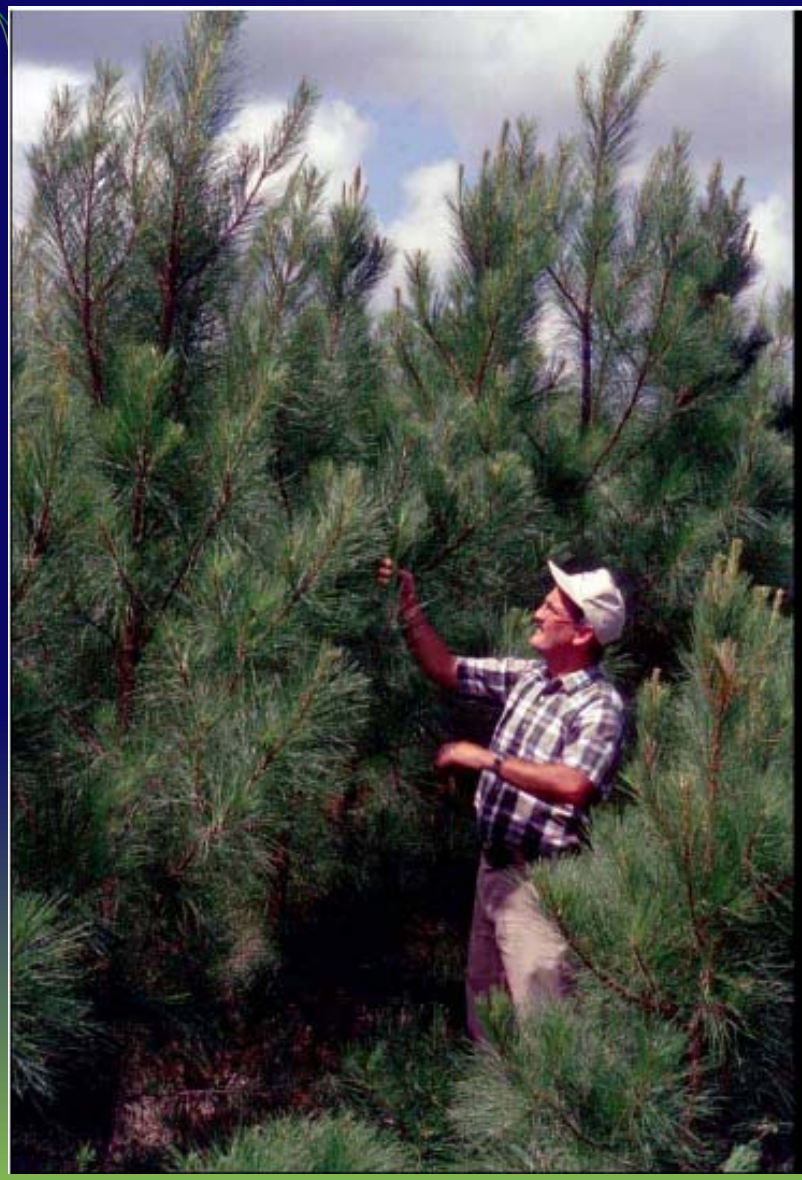

Loblolly pine can be a short-rotation crop

2.5-year-old loblolly pine at 4840 trees per acre, in Robeson Co., NC. Closely-spaced planting regimes such as this can be used to produce both feedstocks for biofuels and traditional forest products on a 20- to 30-year rotation, providing added value to landowners

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Looking to the future

Building partnerships to reach our goals

- NC Department of Agriculture
  - Exploring campus options
  - Biodiesel production facility
- Existing companies and new start-ups
  - Labs
  - Greenhouses
  - Office space
  - Test plots
- Community colleges and universities
  - Student field experiences and Co-op programs
  - Integration of biofuels training into existing programs
    - Bioprocessing
    - Sustainable Agriculture
    - Industrial Systems Maintenance
- Community members, locally and statewide

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Looking to the future

DOE grant request for renewable fuel pilot plants

- Oxford – 8 ton/day plant to convert wood into green gasoline
- Durham – 20 ton/day plant to convert wood into diesel fuel

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Questions

Please visit our web site at

www.biofuelscenter.org