



The Creation and Role of the USDA Biomass Research Centers

CAAFI WebCast

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USDA



UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service



Petroleum imports 2006 to today

- In 2006 US was importing a net 5 m gallons/day petroleum
- In 2014 imports and exports were equal
- In 2016 we were exporting ~ 2 m gal/day

Overview of the USDA Regional Biomass Research Centers

- Origin and purpose of the Centers
- Description of the center concept
- Regional research priorities
- Examples of collaborative research results



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Required Investment to Achieve RFS-2 Biofuel Goals



The first 15 billion gallons:

- *Corn grain ethanol – nearly achieved*
- *About 40% of U.S. corn crop*

The next 21 billion gallons:

- *29 million acres*
- *Represents less than 12% of regional crop and pastureland production areas*
- **527** *new advanced bio-refineries that cost \$168-billion*



Greater Potential Benefits if Efforts are Coordinated



Feedstock Development



Feedstock Production



Feedstock Logistics



Biofuels Conversion



Fuel Testing & Approval



Large Scale Deployment

Supply Chain Systems Approach

USDA & DOE
research &
grant programs

USDA
conservation
programs

USDA risk &
biomass
programs

DoD & DOE
Conversion
research

FAA & DoD
Q/C

EPA REN
Certification

USDA & DOE
commercial
programs

**Industry &
DLA** fuel
purchase
guarantees



Establishment of the USDA Biomass Research Centers



- Presidential Memo, *Biofuels Interagency Working Group (IWG)* – May 5, 2009
- IWG Report *Growing America's Fuels Report* – February 03, 2010
- Secretary Vilsack announcement at the National Press Club – October 21, 2010



USDA Biomass Research Centers

Overview

- Networks of *existing* Agriculture Research Service (ARS) and Forest Service (FS) research locations.
- Coordinate USDA intramural and extramural research efforts.
- Coordinate ARS and FS intramural research occurring across different locations into a comprehensive program.
- Leverage current USDA nation-wide capacity to lead sustainable biomass production research.



U.S. Department of Agriculture Biomass Research Centers
Agricultural Research Service





Original Leadership of the Biomass Research Centers



Regional Coordinators and Leadership Teams

1. SOUTHEASTERN REGIONAL CENTER

ARS Leadership. Booneville, Arkansas (Randy Raper, coordinator) and Tifton, Georgia (Bill Anderson, coordinator).

Forest Service Leadership. Auburn, Alabama (Bob Rummer, coordinator).

2. CENTRAL-EAST REGIONAL CENTER

ARS leadership. Lincoln, Nebraska (Ken Vogel, coordinator).

3. WESTERN REGIONAL CENTER

ARS leadership. Maricopa, Arizona (Matt Jenks, coordinator; Terry Coffelt, associate coordinator).

4. NORTHWESTERN REGIONAL CENTER

ARS leadership. Pullman, Washington (Brenton Sharratt, coordinator).

FS Leadership. Corvallis, Oregon (Bob Deal, coordinator).

5. NORTHERN-EAST REGIONAL CENTER

Forest Service leadership. Madison, Wisconsin (Alan Rudie, coordinator).

Emphasis on Partnerships

- The centers will coordinate their efforts with USDA service agency programs and other Federal agencies
- Coordinate with universities with inclusion of educational and extension goals
- Target partnerships to include 1890's, Tribal Nations, & Hispanic Serving Institutions participation
- Identifying technology innovation partnerships and other commercial opportunities



Research Objectives Supporting Sustainable Biomass Production

- **Increase biomass production efficiency** to increase grower profits and reduce biorefinery transaction costs.
- Optimally **incorporate biomass and other dedicated feedstocks** into existing agriculture and forestry-based systems.
- Address the uncertainties of expanded production up-front to **avoid negative impacts on existing markets and ecosystem services**.
- **Develop and utilize new value-added coproducts** to help enable commercially preferred biorefining technologies.



Themes of Research

- 1) Dedicated feedstock development through genetics and breeding
- 2) Feedstock production protocols
- 3) Logistics of planting, harvesting, and preprocessing
- 4) Feedstock conversion
- 5) Natural resource assessments that lead to life cycle analyses (LCA).

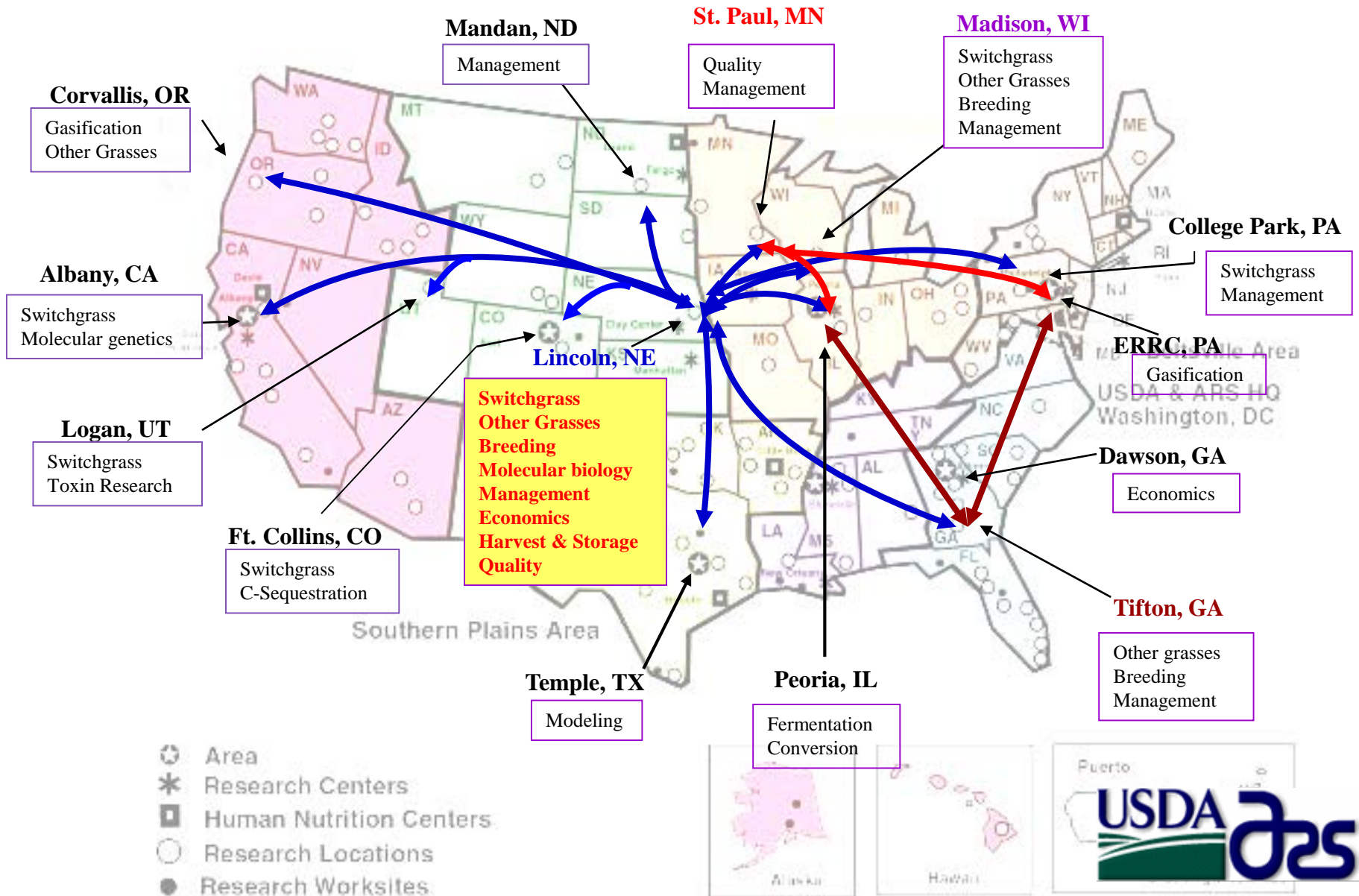


National Natural Resource Networks

- Long-term Agro-ecological Research (LTAR)
- Greenhouse gas Reduction through Agricultural Carbon Enhancement network (GRACEnet)



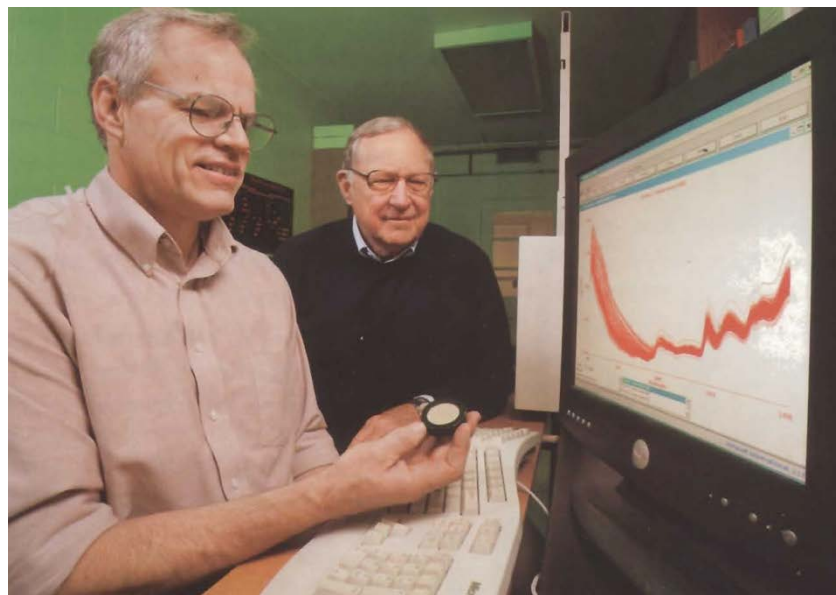
Central - East Regional Center – Corn Residue, Switchgrass and Other Perennial Grasses – Development, Production and Logistics



Central-East Region:

Recent Development of Near Infrared Reflectance Spectroscopy (NIRS) Calibrations for Switchgrass Biomass.

- ARS (Lincoln, NE, St. Paul, MN, Peoria, IL, and Madison, WI) developed comprehensive NIRS calibrations for switchgrass biomass.
- NIRS calibrations - used to accurately estimate over 20 biomass components including cell wall and soluble sugars, and ethanol and released pentose sugars from a laboratory SSF procedure.
- Wet laboratory costs for the same data would cost \$300 to \$2000 per sample; NIRS costs are about \$5 per sample.



Vogel, K.P., B.S. Dien, H.J. Jung, M.D. Casler, S. Masterson, R.B. Mitchell. 2011. Quantifying actual and theoretical biomass ethanol yields for switchgrass strains using NIRS analyses. *Bioenergy Research*. 4:96-110.



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ARS Switchgrass NIRS Calibrations available through the NIRS Consortium (NIRSC)

Search the web 



NIRS Forage and Feed Testing Consortium

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- News and Events
- Programs and Help
- Membership
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- Make Payments



Excellence in Forage and Feed Testing for the Farmer

NIRSC Home

We work together to promote accuracy through uniformity, standardization, and good practices.



The NIRSC is an association of commercial laboratories, universities, government groups, plant research companies, and instrument companies. Our consortium collaborates together to unify knowledge, accuracy, and application of NIRS technology. Laboratories share in efforts and costs to produce standardized calibrations for use. The NIRSC also carries out programs to help and support our members in use of calibrations and instrumentation.

Central-East Region

Switchgrass



Big bluestem



Indiangrass



Corn stover



Biomass sorghum



Native mixtures



'Liberty' switchgrass

First year after Seeding

28 August, 2013
standing crop

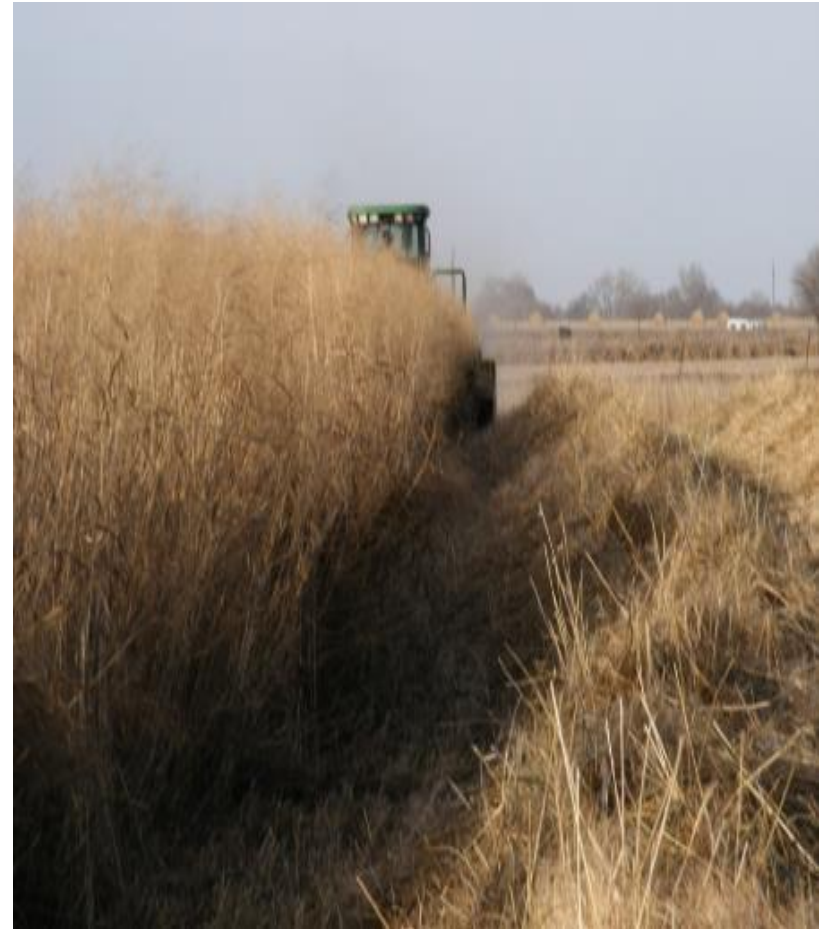
19 November, 2013
5.1 tons/ac
transported off field



‘Liberty’: low-lignin, high cellulose switchgrass

Central Wisconsin 2014-2016

- **Liberty vs. corn**
- **Liberty: marginal land**
- **Corn: best cropping land, producing 200 bu/ac**
- **Ethanol production:**
 - **Liberty: 530 gal/ac**
 - **Corn: 567 gal/ac**



Western Region



Switchgrass



Oil crops:

**Ethiopian
mustard**



Camelina



Guayule

Perennial Grasses

Brachypodium



Big Bluestem



Photo courtesy: SD Game, Fish & Parks

Western Region

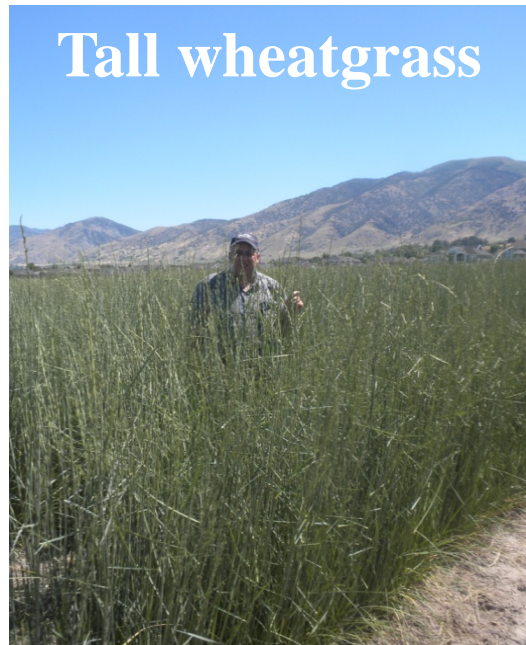


Basin wild rye



No-till corn
Miscanthus
Prairiegrass
Canola
Poplar-tree
sugarcane

Tall wheatgrass



Orchardgrass



Rapeseed



Western Region



guayule

Cooper CS4 tire made completely out of rubber from guayule, a desert shrub that can be grown in the U.S.
Tire Review, Aug. 2015



Bridgestone makes its first tires with guayule rubber. *Rubber and Plastics News, Oct. 2015*

Northwest Regional Center:

Oilseeds, Crop Residue and Forest Products

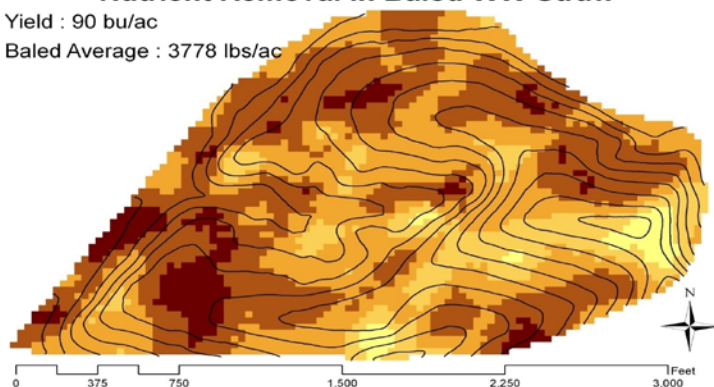
Assessment of Wheat Straw Removal

Testing of Forest Residue Removal

Nutrient Removal in Baled WW Straw

Yield : 90 bu/ac

Baled Average : 3778 lbs/ac



WW N (lbs/ac)	WW P2O5 (lbs/ac)	WW K2O (lbs/ac)	WW S (lbs/ac)
8.53 - 10.54	3.39 - 4.18	19.87 - 24.53	1.83 - 2.26
10.54 - 12.54	4.18 - 4.98	24.53 - 29.20	2.26 - 2.69
12.54 - 14.55	4.98 - 5.77	29.20 - 33.87	2.69 - 3.12
14.55 - 16.55	5.77 - 6.57	33.87 - 38.53	3.12 - 3.55
16.55 - 18.56	6.57 - 7.36	38.53 - 43.20	3.55 - 3.98

WW N (\$/ac)	WW P2O5 (\$/ac)	WW K2O (\$/ac)	WW S (\$/ac)
4.69 - 5.80	2.03 - 2.51	4.97 - 6.13	0.95 - 1.17
5.80 - 6.90	2.51 - 2.99	6.13 - 7.30	1.17 - 1.40
6.90 - 8.00	3.99 - 3.46	7.30 - 8.47	1.40 - 1.62
8.00 - 9.10	3.46 - 3.94	8.47 - 9.63	1.62 - 1.84
9.10 - 10.21	3.94 - 4.42	9.63 - 10.80	1.84 - 2.07

Average \$7.85/ac \$3.40/ac \$8.31/ac \$1.59/ac



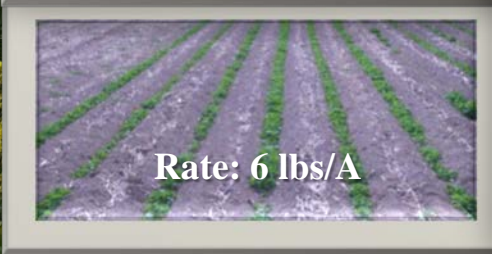
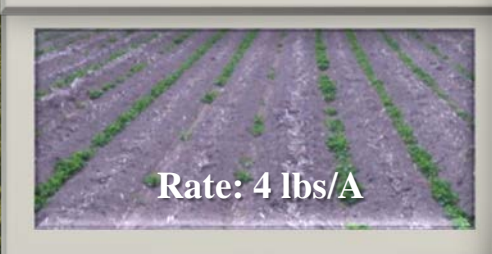
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Northwest Regional Centers:

Increased Canola Production



Canola seeding rate and date



Northwestern Region



Biomass Crops

Industrial Oilseeds

Switchgrass



Polish Mustard



Ethiopian Mustard



White Mustard



Wheatgrass



Oriental Mustard



Oilseed Radish



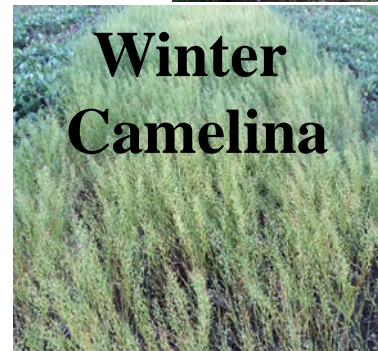
Smooth Brome



Argentine Mustard



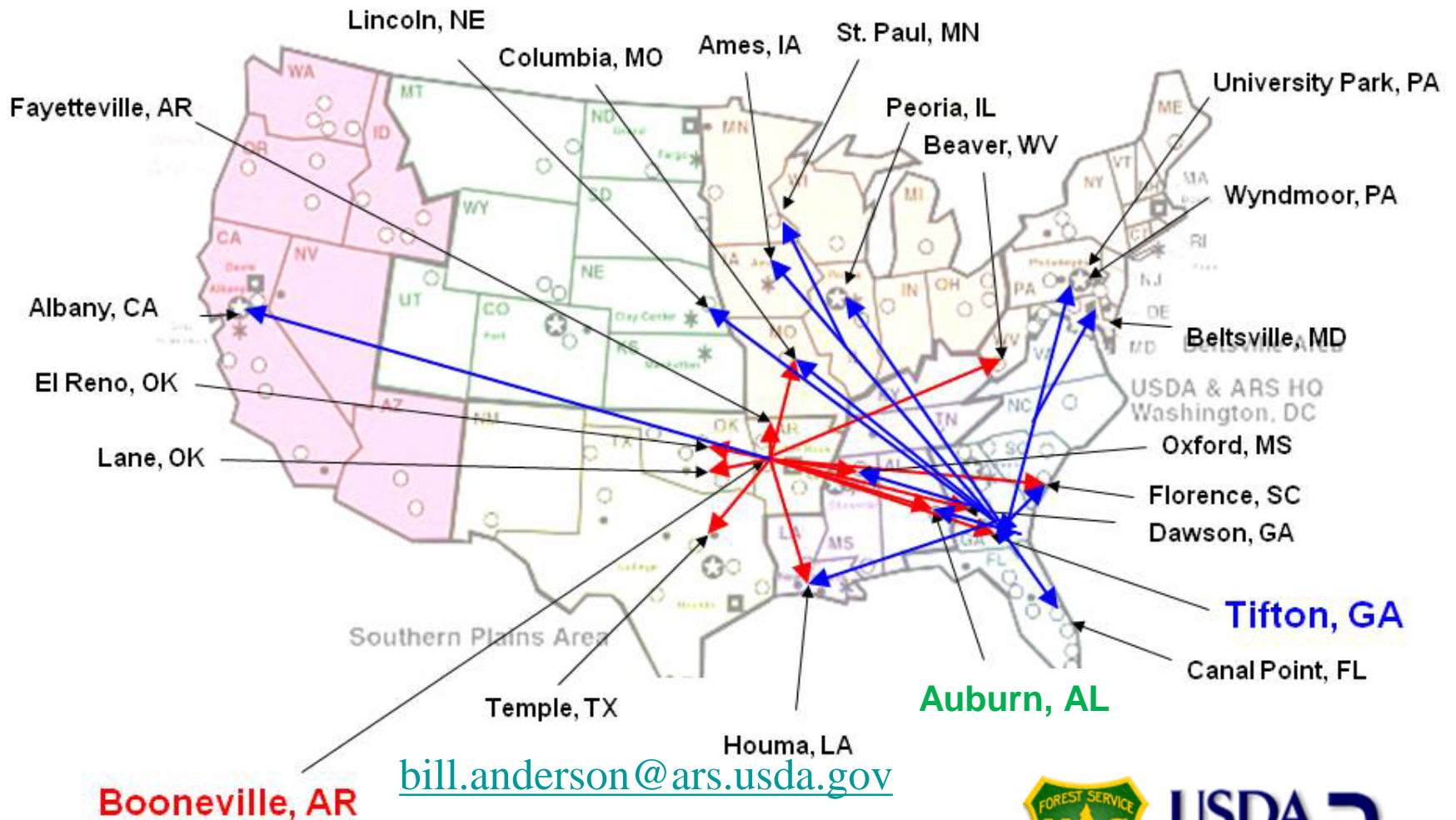
Winter Camelina



Spring Camelina



Southeast Regional Center – Feedstock Development and Production , LCA – Energy Cane, Perennial Grasses, Biomass Sorghum,



Southeastern Region



Bio-energy Feedstocks for the Southeast

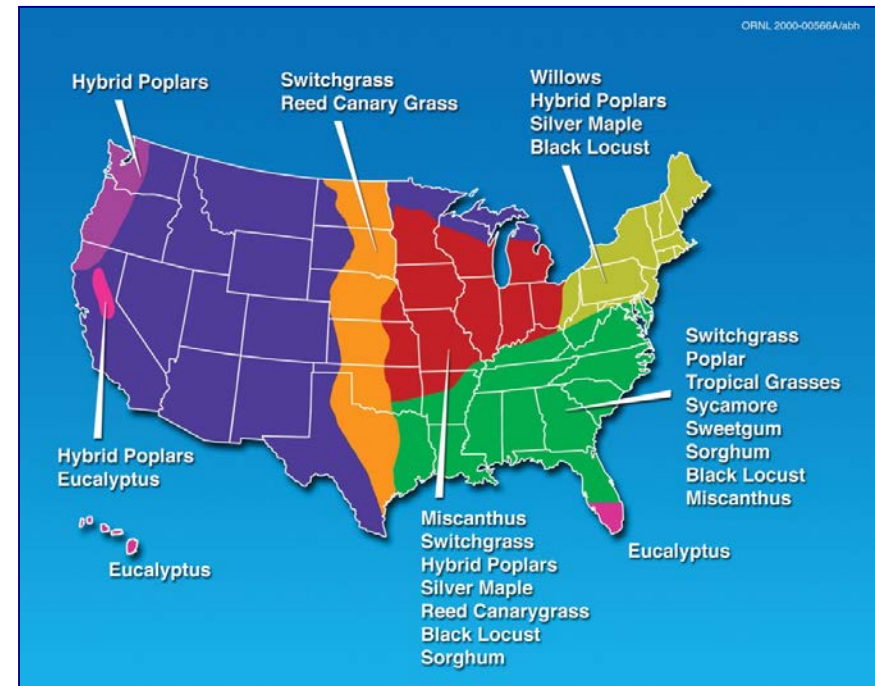


Southeast Regional Center: ALMANAC Crop model

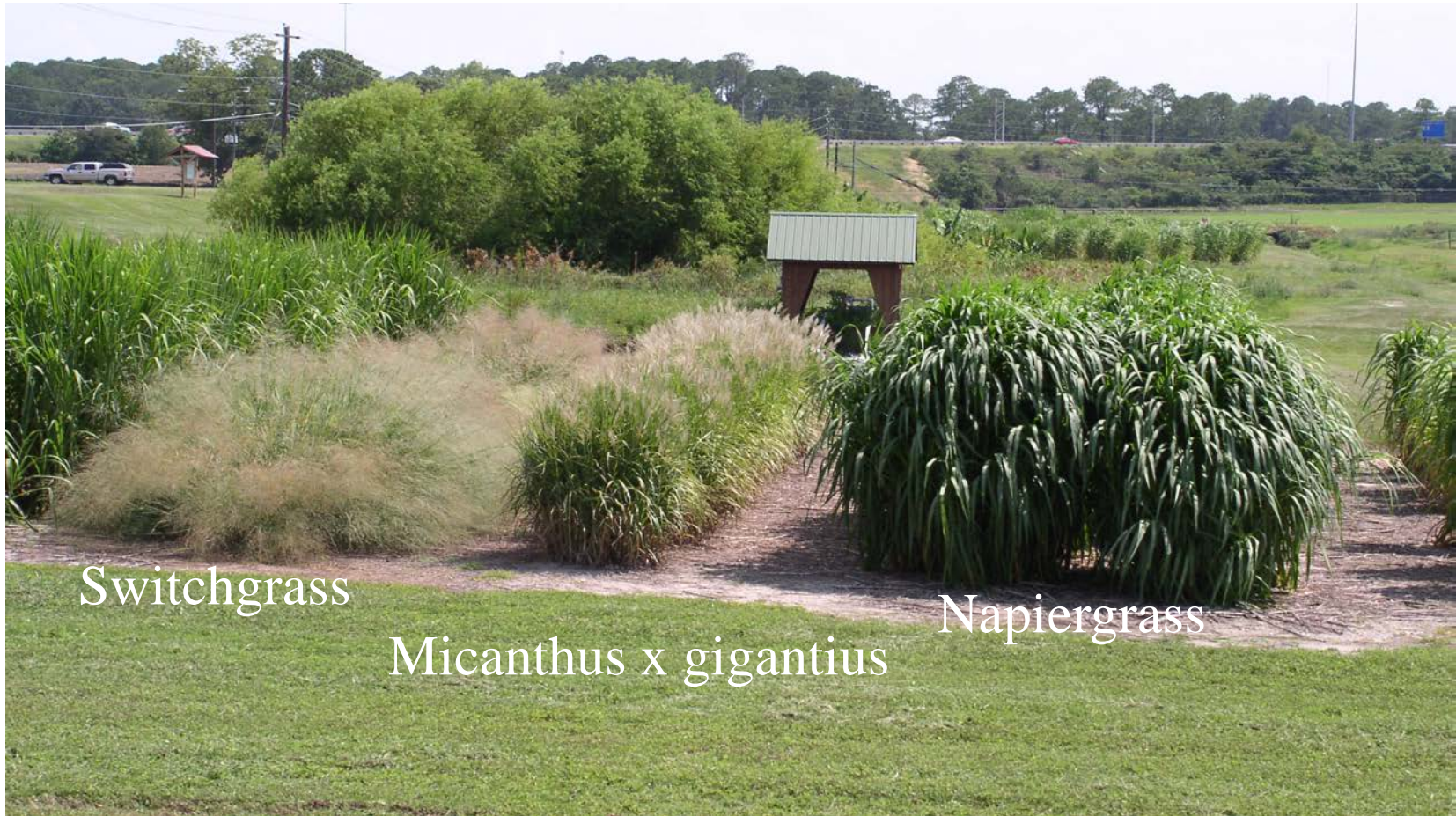
- Simulates plant growth and competition among many plant species
- Functional across various soils, latitudes, and rainfall zones
- Simulates nutrient and water demands
- ALMANAC is free
- Light interception

<http://www.ars.usda.gov/Main/docs.htm?docid=16601>

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Southeast Regional Center: Herbaceous Feedstock Assessment for the Southeast



Switchgrass

Micanthus x gigantius

Napiergrass

Knoll, J.E., Anderson, W.F., Strickland, T.M., Hubbard, R.K., and Malik, R. 2011. Biomass production and nutrient utilization of perennial grasses under no inputs in South Georgia. Bioenerg. Res. DOI 10.1007/s12155-011-9122-x



Brassica carinata (Agrisoma and SPARC)

Regional tests



Conversion to jet fuel



Biomass Bioconversion Center



Bioconversion Research Centers



Three research focus areas:

- **Feedstocks**
- **Conversion technologies**
- **Biofuels/bioproducts**



Biomass Utilization Centers

- **Feedstocks:**
- **Grasses:** switchgrass, miscanthus, napiergrass, big bluestem, corn stover, sorghum, sugarcane, wheat & rice straw, rice hulls, corn bran.
- **Woody biomass:** eucalyptus, forest trimmings.
- **Waste:** processing waste, household waste , manure, distiller grains.



Biomass Utilization Centers

- **Conversion Technologies:**
 - **Hydrolysis**
 - **Enzymatic (catalytic and non catalytic)**
 - **Metal catalysis**
 - **Pyrolysis and torrefication**
 - **Microbial (bacterial, fungi and yeast)**
 - **Anaerobic digestion**

On-Farm Pyrolysis Biorefining.



1 kg ground
corn stover

17,300 BTU



0.75 kg
bio-oil

15,700 BTU



0.2 kg
bio-char

4,000 BTU



0.05 kg
gas

300 BTU

- **Slow – bio-char production**
- **Fast – Bio-oil production**



Biomass Utilization Centers

- **Yeasts:**
 - **New strain with 90% ethanol conversion efficacy reducing cost by \$0.35/gallon.**
 - **New strain that converts coffee waste into ethanol.**
 - **New strain the converts plant xylose into ethanol.**



Biomass Utilization Centers

- **Enzymes:**
 - **Antibacterial lytic enzymes reduces lactic acid bacteria 1000x increasing ethanol yields 10x.**
 - **‘Enzyme-ladder’ linking multiple enzymes improves biofuel production by 70x.**



Biomass Utilization Centers

- **Products from Bioprocessing:**
 - **Discovered an antifungal compound controls potato dry rot disease; chemical 80% failure.**
 - **Discovered antibacterial oil offers low cost control of streptococcus.**



USDA/ARS accomplishments

- BioEnergy Research – June 2016 issue - review articles
- Webpage of Research Center Accomplishments:
- <https://www.ars.usda.gov/natural-resources-and-sustainable-agricultural-systems/biorefining/docs/regional-biomass-research-centers/>