Welcome
To the
MIDWEST BIOENERGY RESEARCH FORUM

U.S. Department of Agriculture (USDA)
Agricultural Utilization Research (ARS)
Midwest Area (MWA)
National Center for Agricultural Utilization Research (NCAUR)

Agricultural Research Service (USDA)

MIDWEST AREA
BIOENERGY RESEARCH FORUM

Scope of ARS-USDA Bioenergy Research: A Panel Discussion

Moderator: **Brian Wrenn**, Research Director,
National Corn to Ethanol Research Center
Conversion: **Michael Cotta**, *ARS Peoria IL*
Sustainability: **Douglas Karlen**, *ARS Ames IA*
Crop Development: **Michael Casler**, *ARS Madison WI*

Role of Biofuels in Sustainable Transportation Energy

- annual U.S. gasoline consumption (2007) = **142 billion gallons**
- annual U.S. ethanol production (2007) = **6.5 billion gallons**
  - on pace to produce about **8.1 billion gals/yr** in 2008
- Energy Independence and Security Act calls for **36 billion gals/yr** of renewable fuels by 2022
  - 21 billion gal/yr from advanced biofuels
  - 15 billion gal/yr from starch-based feedstocks

∴ **achieving the goals of 2007 energy bill will require significant expansion of conventional <u>and</u> advanced biofuels**

- development and demonstration of new technologies
- introduction and evaluation of new feedstocks
- training of expanded workforce
- developing sustainable production practices

National Corn-to-Ethanol Research Center

workforce training

pilot plant

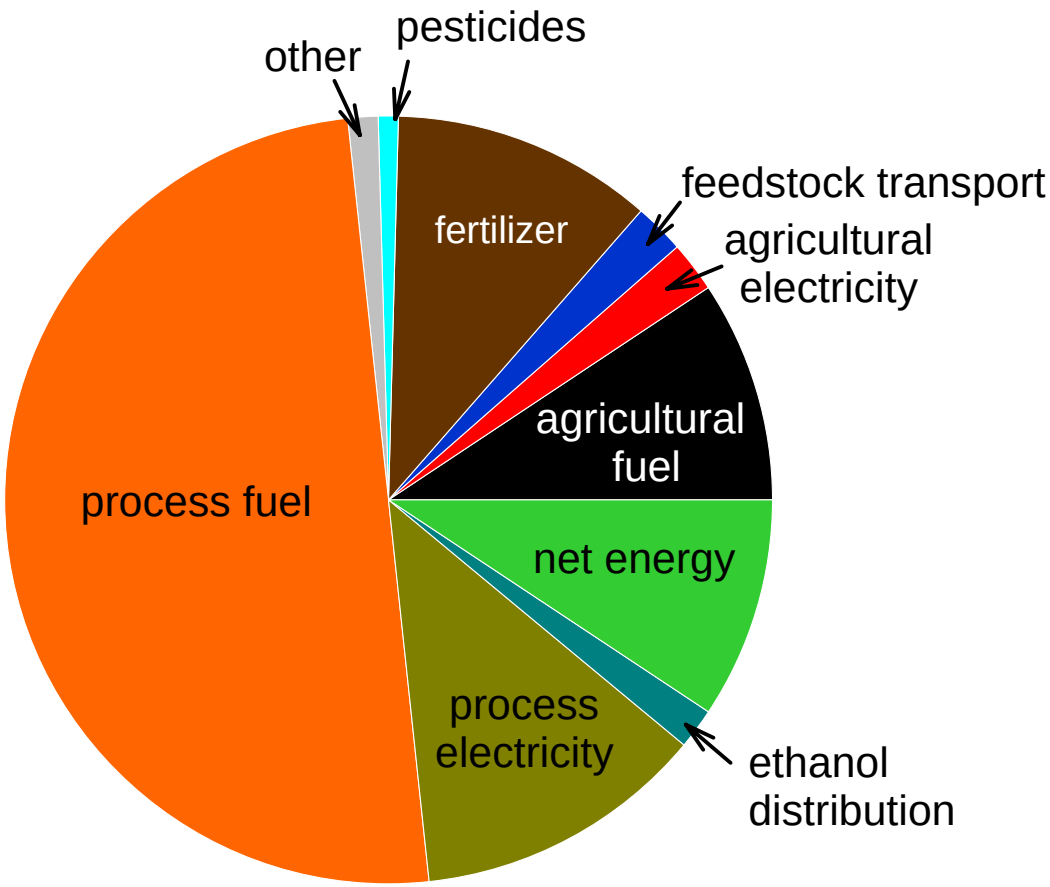
fermentation lab

analytical lab

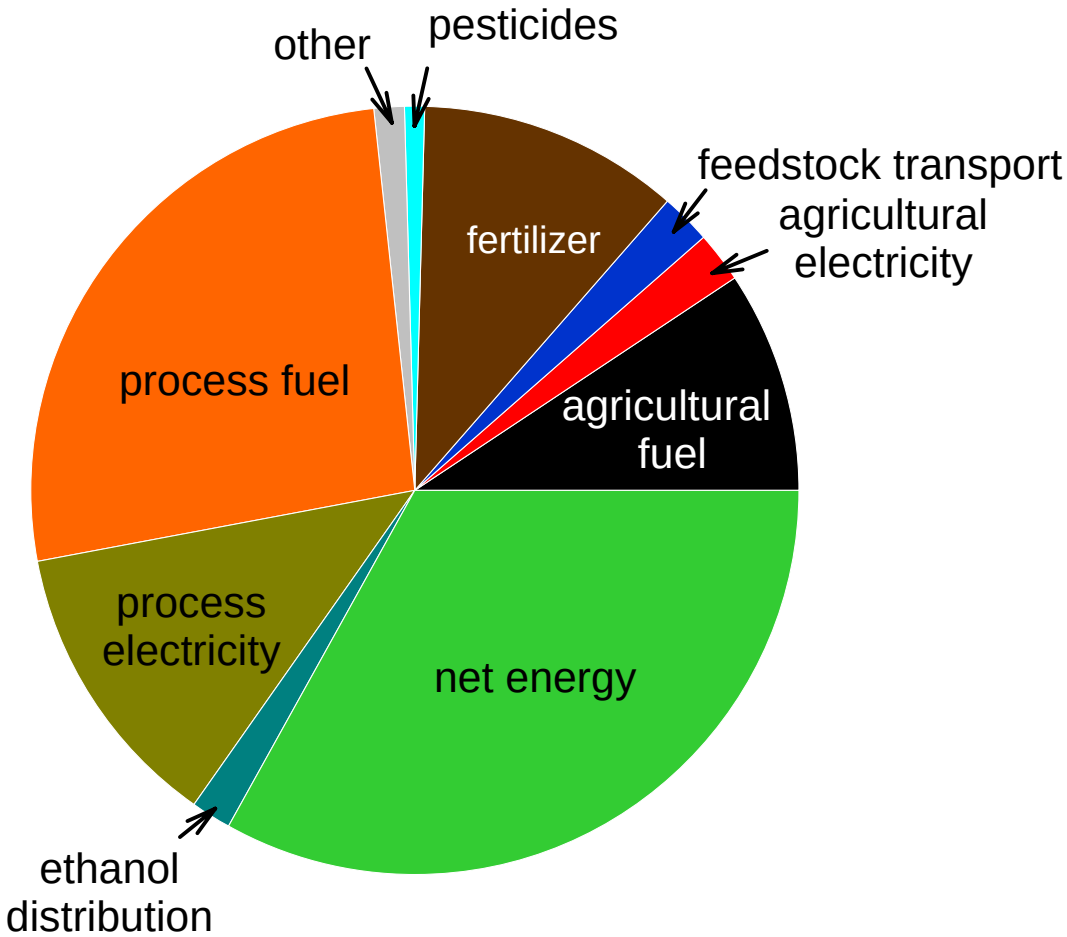
Research Needs in Starch-Based Ethanol Production

- effects of anaerobic digestion of thin stillage on energy balance
- control of bacterial contamination
  - alternatives to antibiotics
  - rapid and sensitive methods for monitoring fermentation progress
- factors affecting DDGS nutritional quality
  - operating conditions (*e.g.*, fermentation completeness, dryer temperature, syrup application rate)
  - DDGS risk factors (*e.g.*, sulfur, mycotoxins)
- alternative starch-based feedstocks
  - effects of dry fractionation on ethanol yield and coproduct quality
  - high-fermentable corn hybrids and other grains
  - materials-handling characteristics of nonfermentable solids

Energy Balance Without Anaerobic Digestion



Energy Balance With Anaerobic Digestion



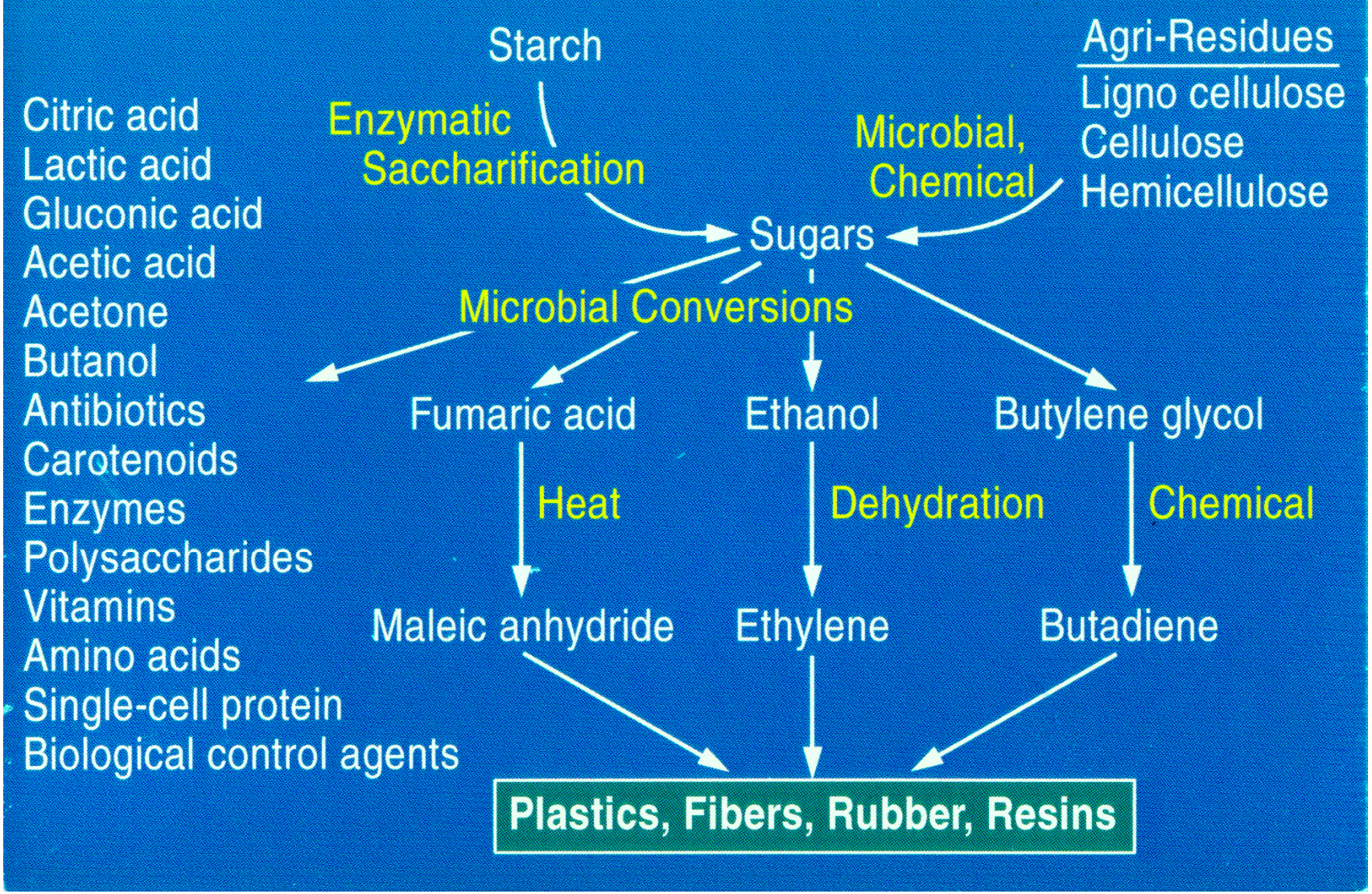
ARS Bioenergy and Energy Alternatives Research

- Ethanol (and Butanol)
- Biodiesel
- Thermo-chemical
- Alternatives
  - Wind
  - Biogas
  - Hydrogen

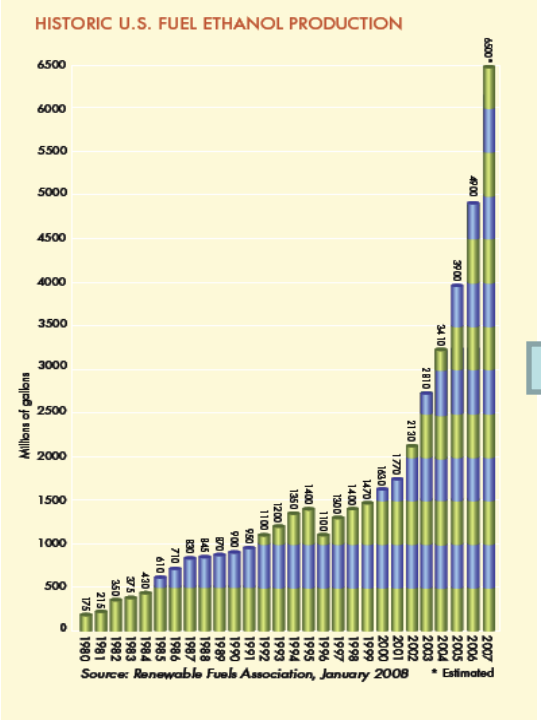
National Program 307 Locations

- Emphasis on Conversion Research
- Underestimates the real biofuels research effort

Useful Products from Agricultural Materials



Historically from Corn and other grains



Still support this effort

- Add value to coproducts (e.g. DDGS)
- Improve process efficiencies
- Control contamination

Energy Independence Act, 2007:
36 billion gallons by 2022

New Renewable Fuels Standard Schedule

Year	Renewable Biofuel	Advanced Biofuel	Cellulosic Biofuel	Biomass based Diesel	Undifferentiated Advanced Biofuel	Total RFS
2006	9.0					9.0
2009	10.5	.6		.5	0.1	11.1
2010	12	.95	.1	.65	0.2	12.95
2011	12.6	1.35	.25	.8	0.3	13.95
2012	13.2	2	.5	1	0.5	15.2
2013	13.8	2.75	1		1.75	16.55
2014	14.4	3.75	1.75		2	18.15
2015	15	5.5	3		2.5	20.5
2016	15	7.25	4.25		3.0	22.25
2017	15	9	5.5		3.5	24
2018	15	11	7		4.0	26
2019	15	13	8.5		4.5	28
2020	15	15	10.5		4.5	30
2021	15	18	13.5		4.5	33
2022	15	21	16		5	36

In recent years, switch focus to lignocellulose rich feedstocks

- Coproducts [corn fiber]
- Crop residues
- Dedicated energy crops

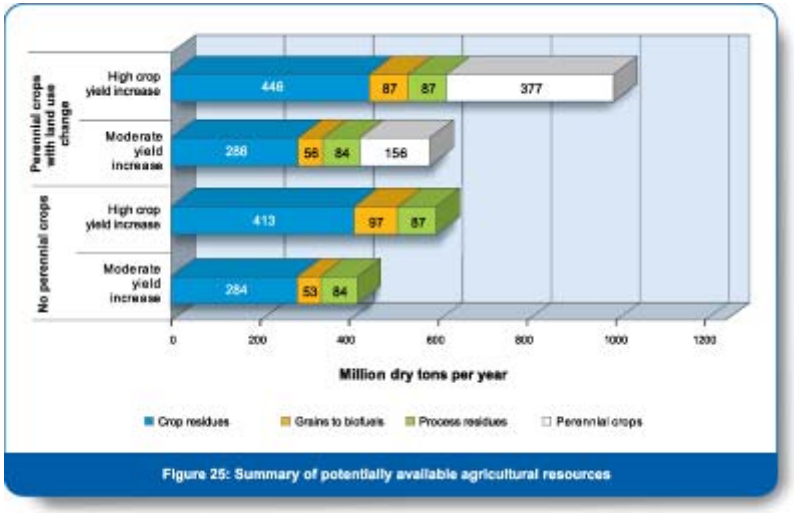
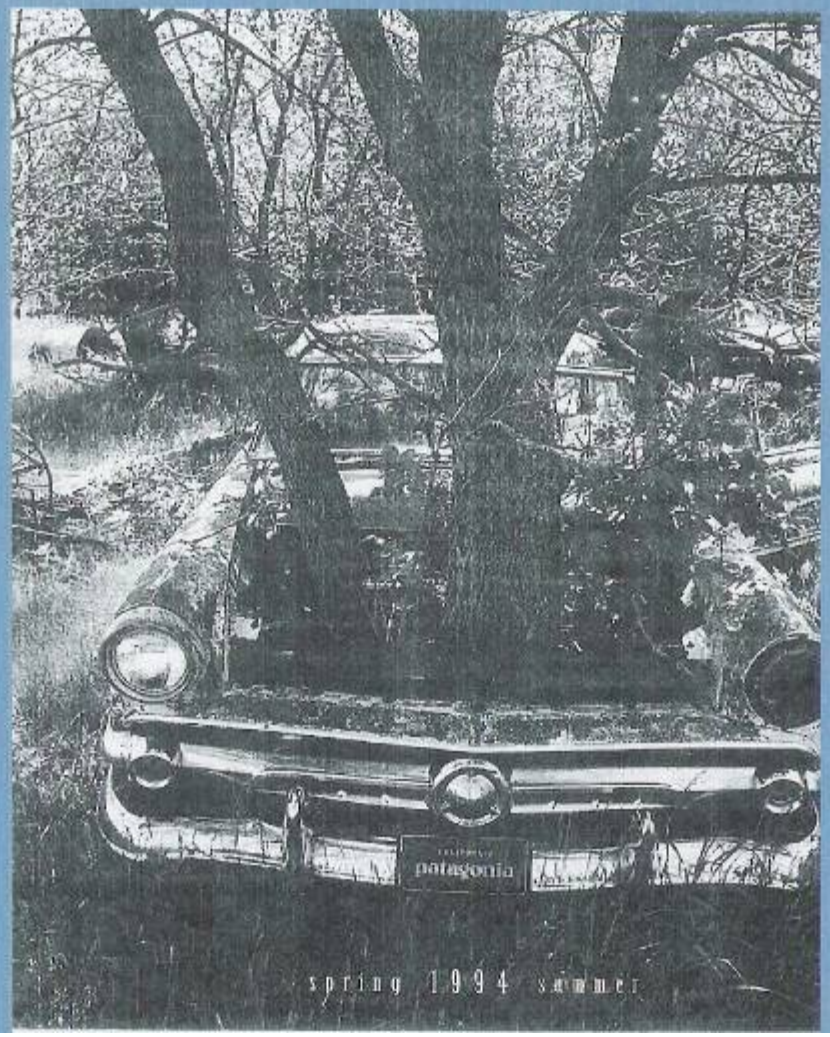


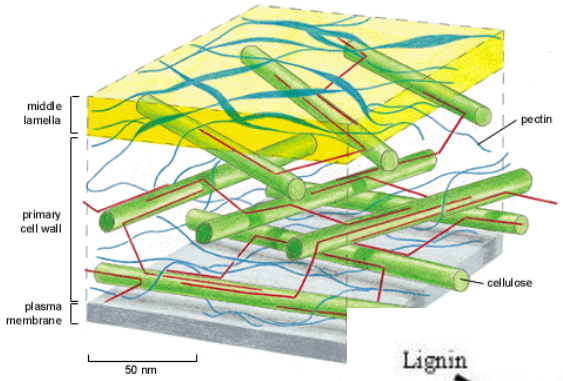
Figure 25: Summary of potentially available agricultural resources

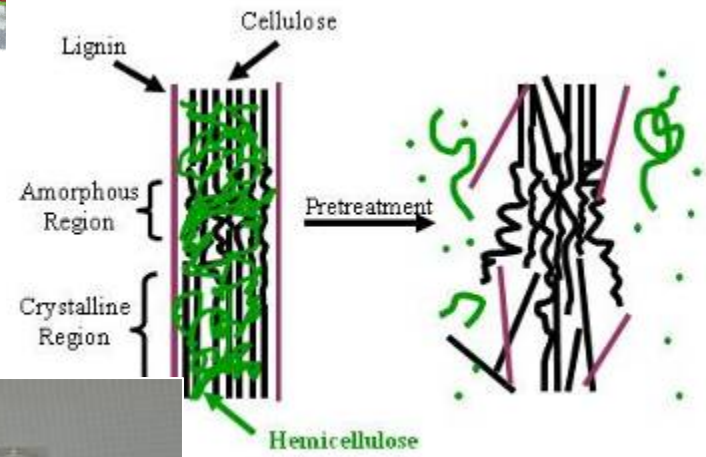
How Do You Put Low Cost Biomass in Your Automobile?



Challenges to conversion of biomass feedstocks to fuels

- Low density feedstoc
- Costly pretreatment
- Inhibitors
- Inefficient enzymes
- New biocatalysts needed
- Low coproduct value
- Product recovery

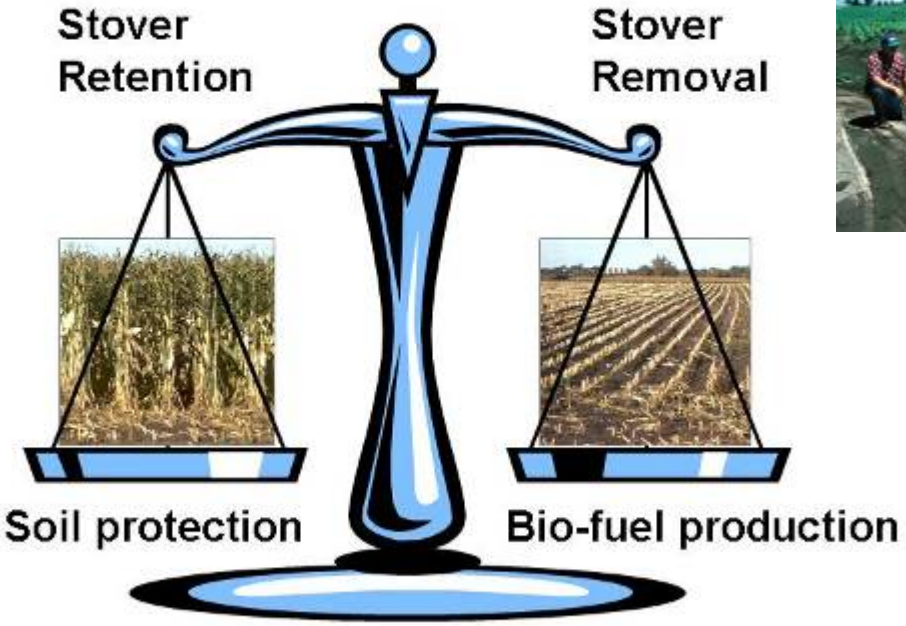




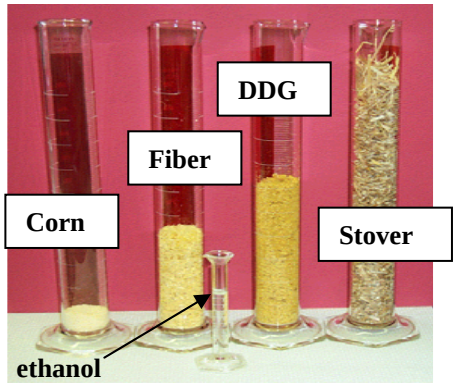
What's being done to overcome these?

- ✓ Feedstock/ Energy Crop development
- ✓ Pretreatment Strategies
- ✓ Enzymes for conversion of biomass polysaccharides to fermentable sugars
  - Enzyme expression systems
  - Discovery of new enzymes/ exploitation of novel sources
- ✓ New Biocatalysts for production of ethanol
  - Recombinant bacterial strains
  - Yeast strain improvement
  - Inhibitor resistance
- ✓ Bioprocess Engineering
  - Product recovery
  - Reactor design

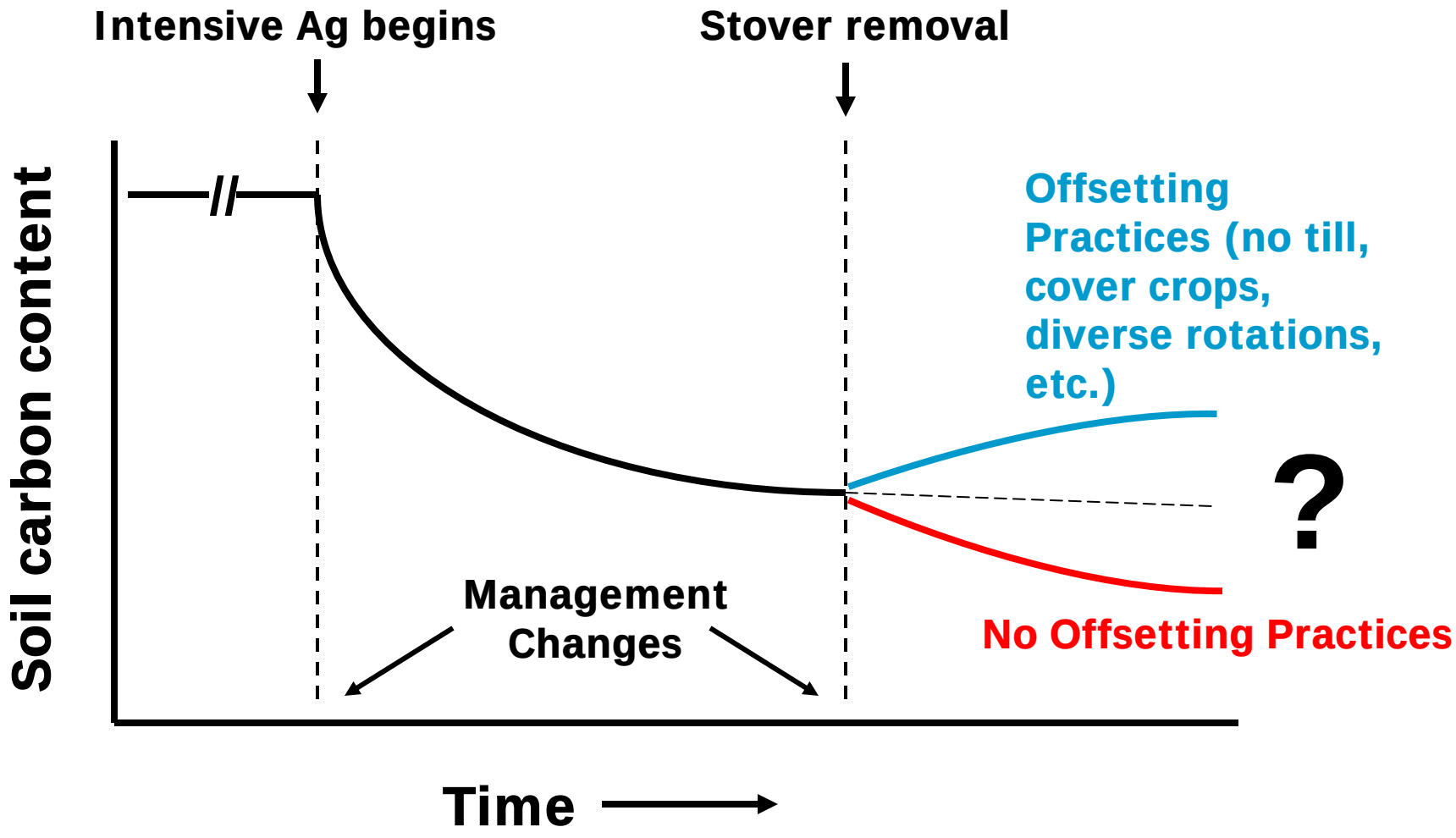
Soil Conservation - Bio-energy Balance



A challenging balancing act!



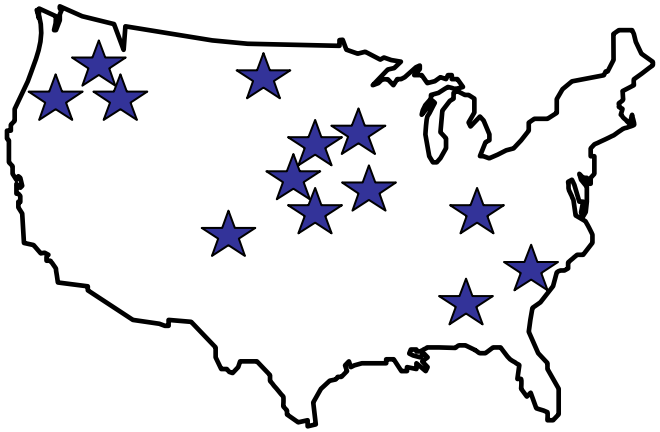
Soil Carbon and Sustainability



Renewable Energy Assessment Project (REAP)

VISION

Sustainable Feedstock Production & Harvest

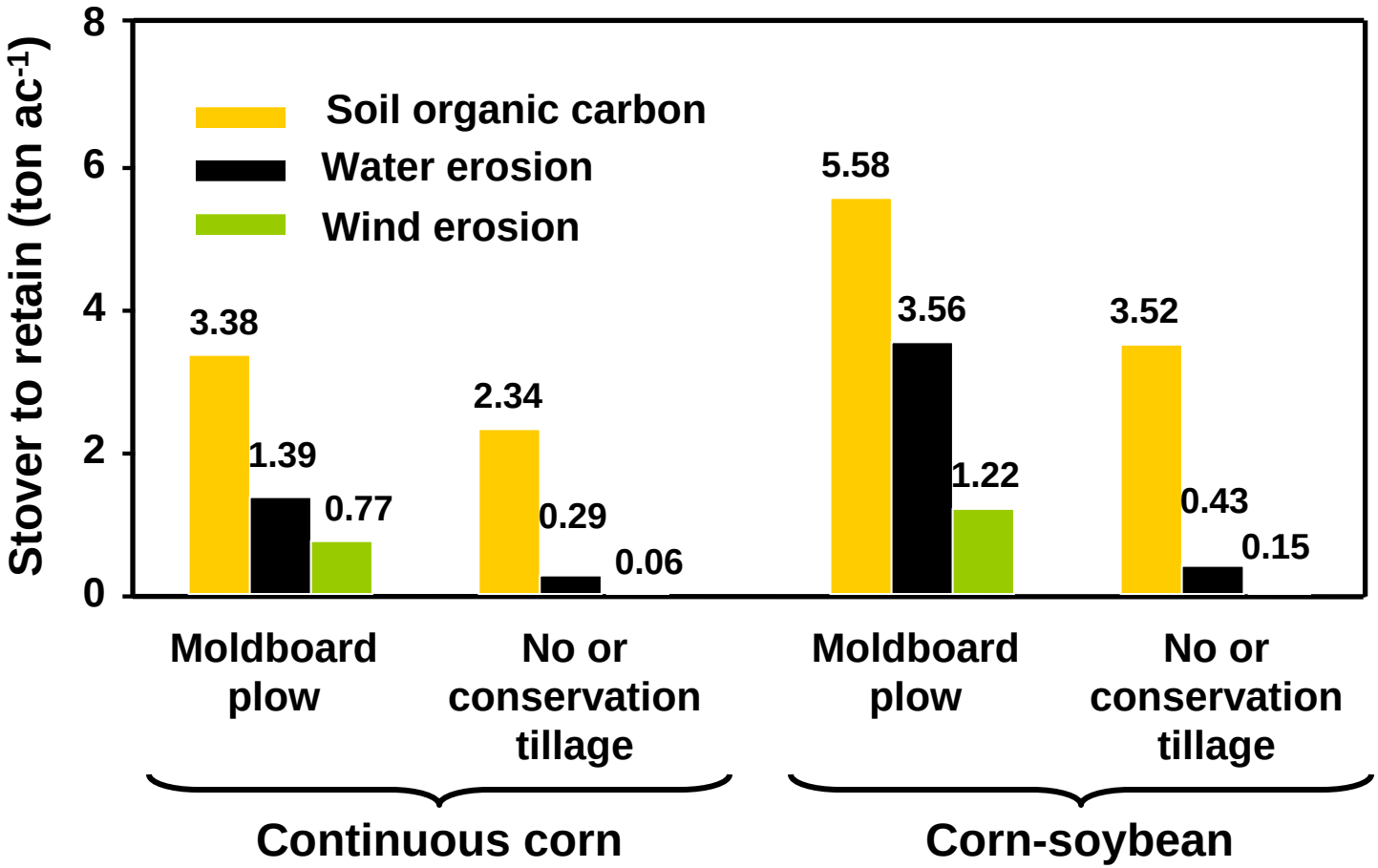


- Management practices
- Algorithms to guide sustainable harvest
- Decision support tools
  - How much residue must be retained?
  - Quantify benefits associated with retaining crop residues

REAP has and welcomes more University, Industry and Federal Partners

Critical REAP Assessment

From Wilhelm et al. (2007)



Critical Take-Home Point

Crop residues are not trash!

They have multiple roles that help sustain soil resources

Economic growth that destroys ecological support systems is neither sustainable nor true progress

ARS National Action Plan: Feedstock Development

- Breeding and Evaluation of New Germplasm
  - Many species (annuals, perennials, grasses, legumes)
  - Regional evaluations and regional deployment
  - Field and laboratory traits (agronomic and conversion)
- Biological and Molecular Basis of Plant Traits
  - Biological and molecular processes
  - Stress tolerances, Biomass yield, Recalcitrance of biomass
  - New genetic, genomics, and bioinformatics tools
  - Gene discovery and cross-species genetic homology
- Cooperation and collaboration between “breeding” and “molecular” groups.

Feedstock Development: Technical Barriers to Overcome

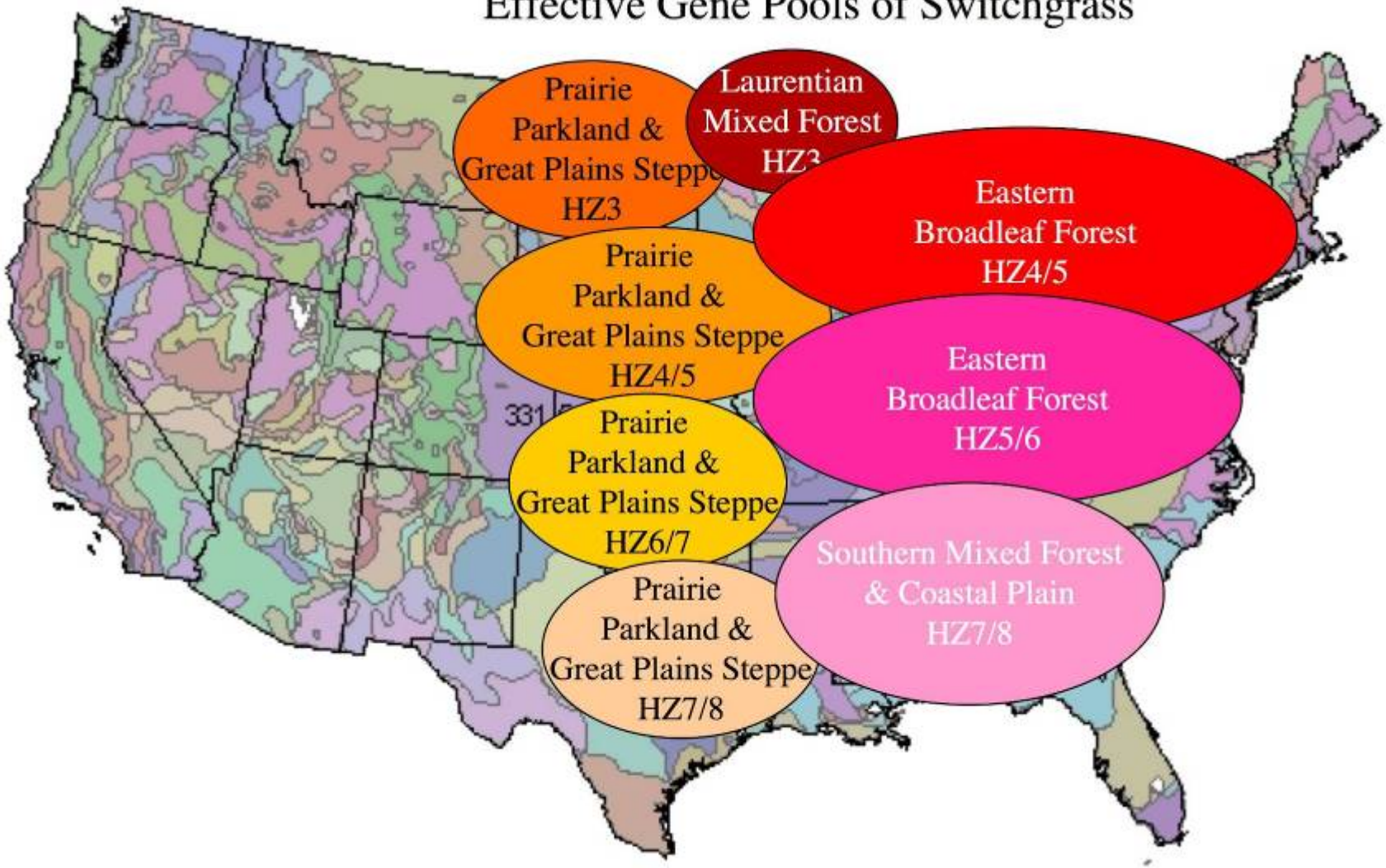
- Feedstock traits that affect conversion efficiencies
- Germplasm collection and characterization
- Large-scale screening tools for feedstock traits
- Molecular (gene-based) breeding tools
- Low photosynthetic efficiency of plant “machinery”
- Identity of all genes involved in cell-wall synthesis
- Cultural and disciplinary differences between groups of scientists within the scientific community, particularly between plant breeders and molecular biologists

Feedstock Development in the Midwest Area

- Madison, Wisconsin
  - Switchgrass (warm-season, tallgrass prairie)
  - Reed canarygrass (cool-season, wetlands)
  - Big bluestem (warm-season, tallgrass prairie)
- St. Paul, Minnesota
  - Alfalfa (biomass-type, 2-cut harvest management)

- Focus on cellulosic conversion - fermentation to liquid fuels and thermoconversion to generate heat
  - Effect of lignin on conversion efficiency (multiple platforms)
  - Agronomic effects of reduced lignification

Effective Gene Pools of Switchgrass



Breeding a Biomass-type Alfalfa for 2-cut Harvest Management

Biochemical Conversion: Fermentation to Ethanol

Theoretical Ethanol Yields:
Differences in cell wall composition/concentrations due to:

Management treatments:

Hay Management	Biomass Management	Difference
73.3 gal/Ton	78.1 gal/Ton	6.5%

Germplasms:

Hay Type	Biomass Type	Difference
74.3 gal/Ton	77.4 gal/Ton	4.2%

Difference in cell wall composition/concentration and DM yield:

Hay Type Hay Management	Biomass Type Biomass Management	Difference
164 gal/acre/yr	326 gal/acre/yr	99%

Combination of Genetics, Management, Planting density

Agricultural Research Service (USDA)

MIDWEST AREA BIOENERGY RESEARCH FORUM

Steven Shafer,
ARS Deputy Administrator for Natural Resources and Sustainable Agricultural Systems

USDA-ARS Midwest Area Bioenergy Showcase

Steven Shafer, USDA-Agricultural Research Service
USDA-ARS National Center for Agricultural Utilization Research
Peoria, Illinois
July 18, 2008

ARS National Program on Bioenergy

Goals for the Bioenergy Mission

- Enable new varieties and hybrids of bioenergy feedstocks with optimal traits
- Enable new optimal practices and systems that maximize the sustainable yield of high-quality bioenergy feedstocks
- Enable new, commercially preferred biorefining technologies

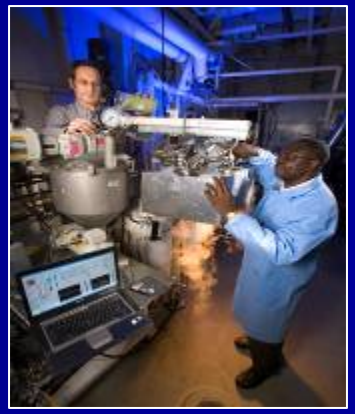
The Sustainability Challenge

Meeting current demands for biofuels feedstocks without eroding the potential to meet future needs for other agricultural goods and services.

Utilizing the emerging capacity to understand the effects of agricultural practices and policy decisions on economic returns and environmental consequences.

USDA-ARS
Research Needs for Sustainable Biofuels

1. Strategies to increase feedstocks amounts that can be sustainably harvested.
2. Analytical tools simulating crop, biophysical, and economic functions that can be applied across environments.
3. Integrate assessments of the biofuels supply chain impacts for different sectors at multiple scales.
4. Develop high-performing whole systems integrating feedstock development, production, and conversion components.



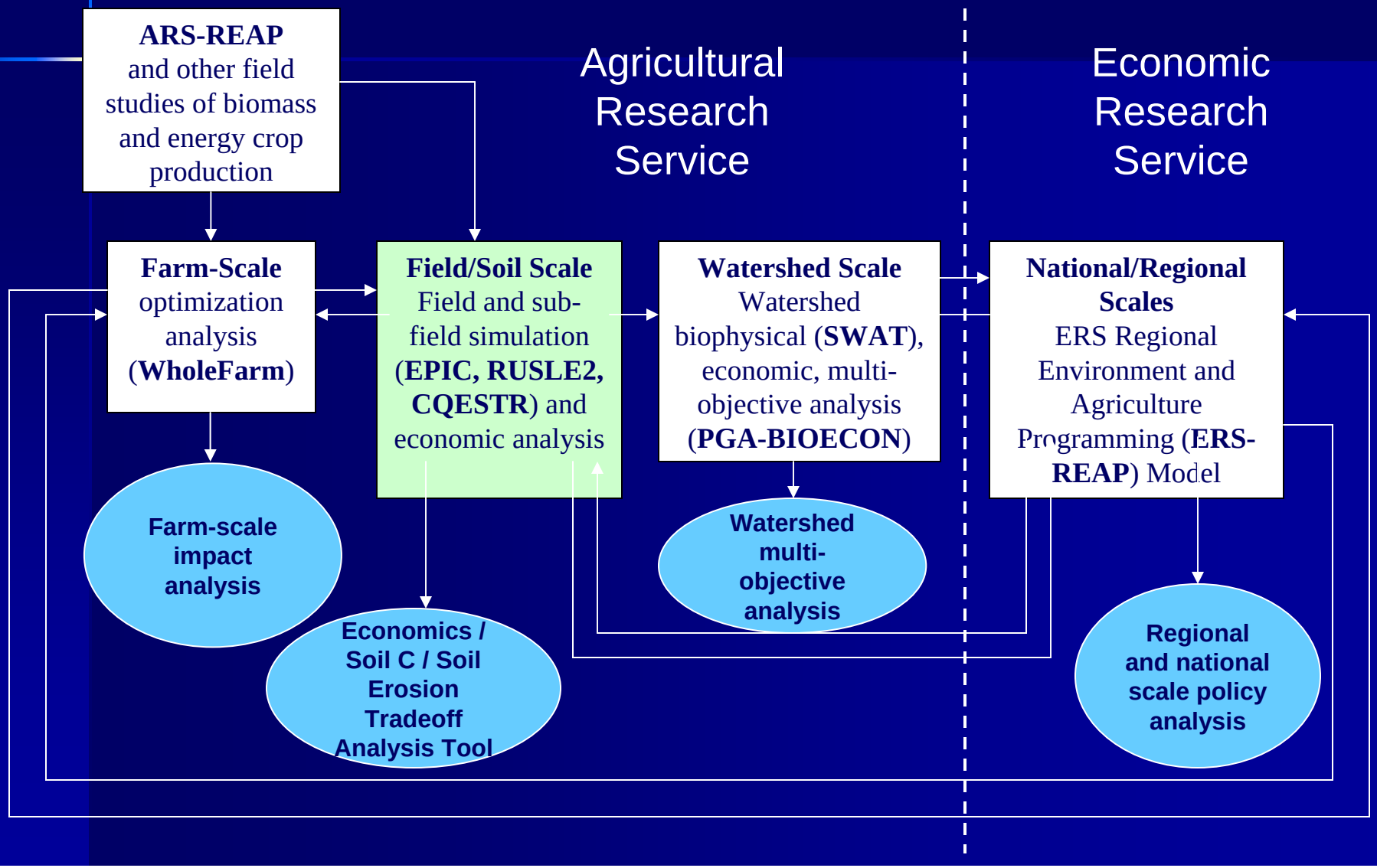
Sustainable strategies to increase feedstocks amounts that can be harvested

- Develop new crops and varieties that have good characteristics for use as energy feedstocks.
- Develop cover crops to enhance soil carbon for greater biomass removal.
- Identify rotation configurations to incorporate energy production into existing food and feed systems.
- Develop sustainable practices for use of perennial forages as feedstocks.

Analytical tools simulating crop, biophysical, and economic functions that can be applied across environments

- Mechanistic models that predict the effects of management and changing climate on biomass production and crop yield.
  - Biophysical models to predict the effects of feedstock production on natural resources processes and quality.
    - Integrated linkage of models to answer questions at different scales.

Integrate assessments of biofuels supply chain impacts for different sectors at multiple scales



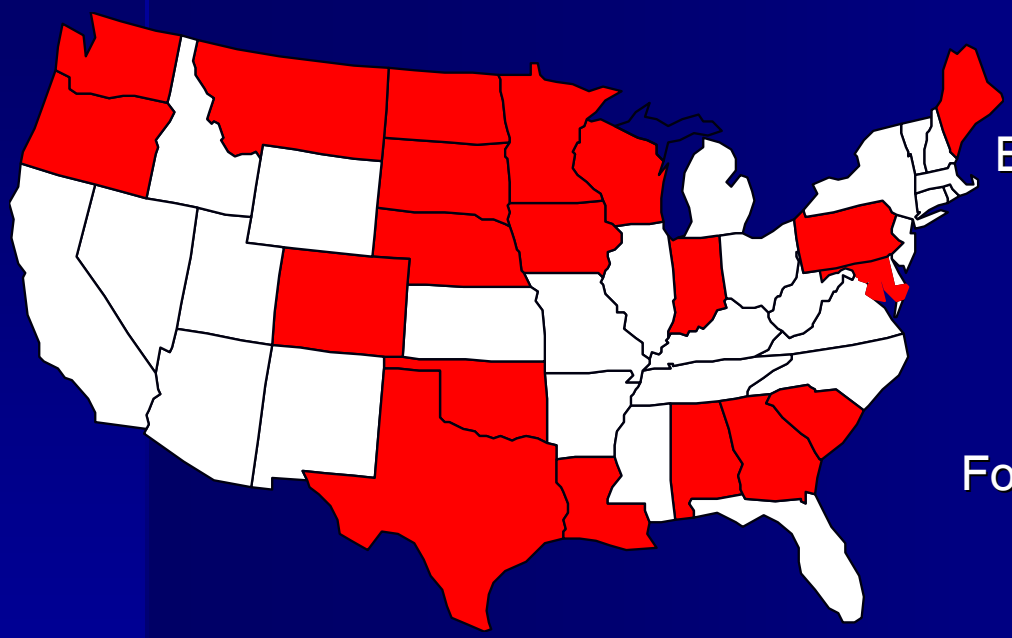
Develop high-performing whole systems integrating feedstock development, production, and conversion components.

Switchgrass

- Germplasm assessed and adapted cultivars developed for traits specific to biofuels use.
- Management practices to that ensure high agronomic production.
- Economic assessment of production costs, including logistics.
- ALMANAC switchgrass growth simulation model.
- Production and environmental impact validated for EPIC & SWAT models.

USDA-ARS Bioenergy Sustainability Research

Contributing Locations



Ames, IA
Auburn, AL
Beltsville, MD
Brookings, SD
Corvallis, OR
Dawson, GA
El Reno, OK
Florence, SC
Fort Collins, CO
Homa, LA
Lane, OK
Lincoln, NB
Madison, WI
Mandan, ND
Morris, MN
Orono, ME
Pendleton, OR
Prosser, WA
Pullman, WA
Sidney, MT
St. Paul, MN
Temple, TX
University Park, PA
Watkinsville, GA
West Lafayette, IN

For more information

- National Program Overview for ARS research on bioenergy

  http://www.ars.usda.gov/research/programs/programs.htm?np_code=307

- Click the link on that page for the full 2008-2013 Action Plan

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Thank you for your participation.

Please enjoy the poster presentations and tour