Overcoming Challenges with Emerging Biomass Technologies What is possible? When?

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USDA Agricultural Research Service


Agricultural Science:
A key to food and energy security
and natural resources stewardship
in 21st Century.
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USDA ARS

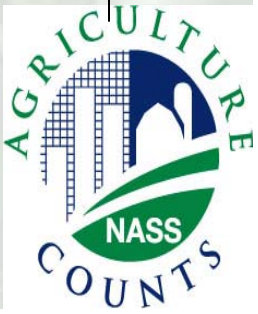
Program Drivers
Presidential Initiatives

- **Advanced Energy Initiative (2006)**
  - Reduce dependence on foreign oil sources
  - Cellulosic ethanol – cost competitive by 2012
  - Improve vehicle efficiency; and solar initiatives
- **"Twenty-in-Ten" (2007)**
  - Increase supply of renewable and alternative fuels
    - Goal: Produce 35 billion gallons/year by 2017
  - Increase vehicle efficiency
    - Goal: Reduce annual gasoline use by 8.5 billion gallons by 2017

Research, Education, and Economics

USDA
Secretary of Agriculture

Under Secretary
for
Research, Education,
and Economics (REE)



ARS Bioenergy R&D Goals

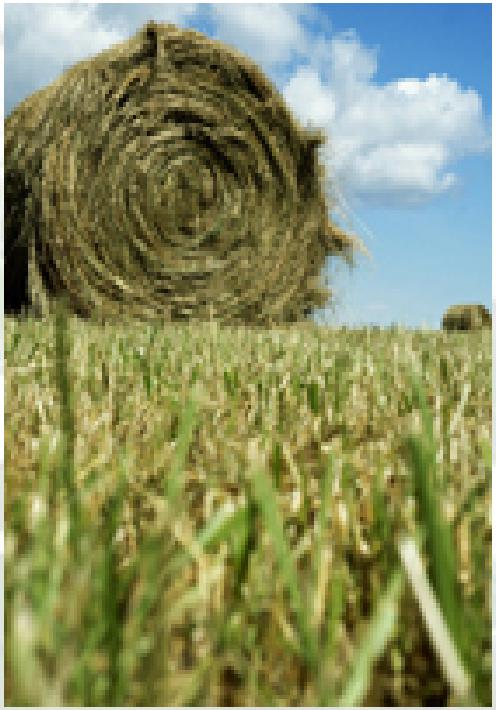
- **Energy Crop Varieties**
  Advance the development of biorefinery feedstock for every agricultural region in the Nation.
- **Feedstock Production Practices**
  Develop practices that maximize sustainable producer income for every agricultural region in the Nation.
- **Biorefinery Processes/Co-products**
  Enable the development, in the shortest possible time-frame, of commercially-preferred biorefinery conversion processes and biorefinery co-products

The Sustainability Challenge

Servicing current demands from agriculture without eroding the potential to meet future needs/obligations.

ARS Bioenergy Program

1. Feedstock Development
2. Feedstock Production
3. Conversion & Co-Products
4. Integration



1. Feedstock Development

A. Breeding and evaluation of new germplasm

- Improved breeding methods
- Evaluate for specific adaptation zones
- Identify/incorporate plant traits that enhance energy production
- Develop rapid/reliable methods for measuring desirable traits
- Conduct risk analyses *(gene flow, invasive sp.)*
- Improved germplasm & varieties for energy crops

1. Feedstock Development (cont.)

B. Biological & molecular basis of plant traits

- DNA markers & genetic maps for bioenergy
- Identify and validate candidate genes that improve key bioenergy traits
- Understand inheritance mechanisms in complex polyploid perennials
- Understand molecular basis for key traits *(cell-wall structure, growth biomass yield, conversion potential)*

2. Feedstock Production

A. Region-specific, sustainable practices to maximize feedstock harvest

Whole-farm optimization tool incorporating bioenergy production from crop residues, dedicated energy crops & post-harvest processing by-products

Cover crops that increase annual biomass yield and enhance soil carbon & nitrogen

Rotation configurations that incorporate bioenergy production into food, feed & fiber systems

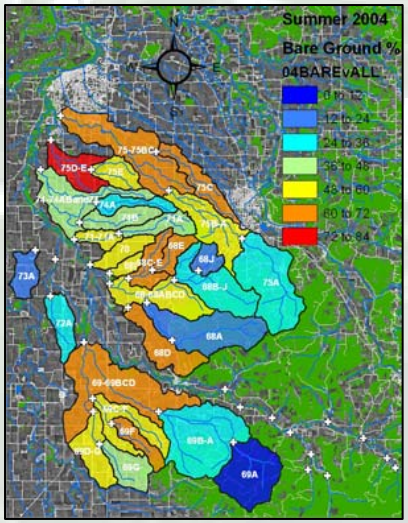
2. Feedstock Production (cont.)

B. Analytical tools to estimate potential feedstock amounts and the implications of harvest

Operations management tools for feedstock production that consider climate, weather and soil conditions

Models to predict effects & risks of feedstock production on economics, natural resources quality, and ecological systems services

Decision tools for farmers and biorefinery operators



2. Feedstock Production (cont.)

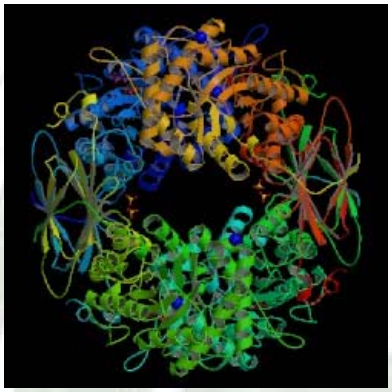
C. On-farm utilization of byproducts

Physical, chemical and biological value of byproducts as soil amendments and nutrients

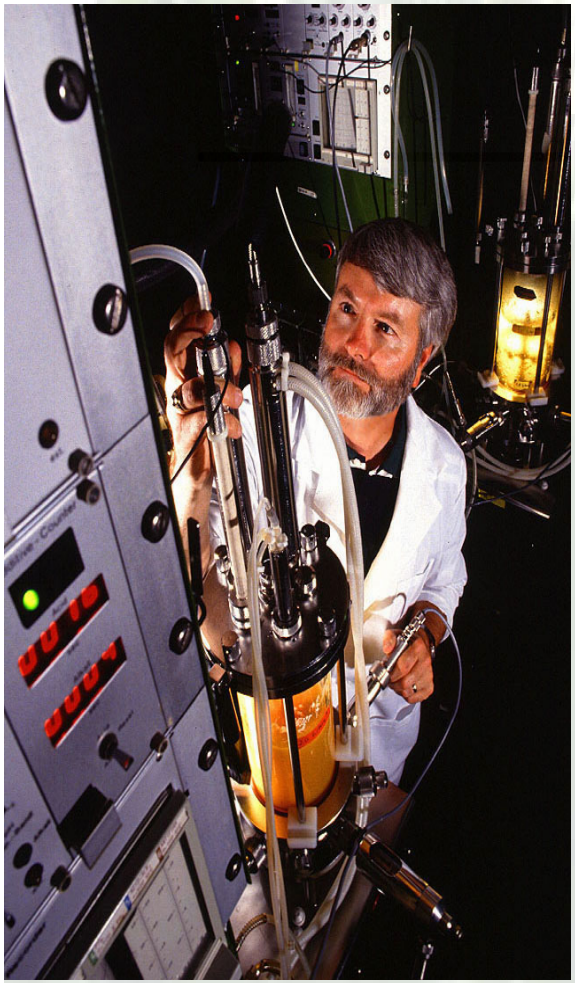
- **ethanol by-products**
- **gasification ash**
- **bio-char**
  - **NSTL – Ames, IA**
  - **glomalin – Mandan, ND; Beltsville, MD**
  - **pyrolysis – Wyndmore, PA**
  - **peanut hull char – Florence, SC**
  - **testing Eprida product – Morris, MN**

3. Conversion & Co-Products

- **Reduce conversion costs for cellulosic ethanol**
  - **new and improved hydrolysis enzymes**
  - **inhibitor-resistant microbes**
- **Develop thermochemical processes for near-to-the-farm production of energy or intermediate products**
- **Develop value-added co-products**
  - **from lignin, hemicellulose, char, ash**
  - **microbial products (e.g., adhesives)**
  - **new plant-produced products**



3. Conversion & Co-Products (cont.)



- **Biochemical (to EtOH & BuOH)**
  - starches & sugars (value-added co-products)
  - cellulosics
    - preprocessing and pretreatment (especially on-farm)
    - help ID key feedstock/crop traits
    - lower cost
    - increase energy efficiency
    - minimize water requirements
    - co-products
- **Biodiesel**
  - fuel quality (cold flow, oxidative stability, contaminants)
  - glycerol and protein-meal co-product
  - next generation feedstock

3. Conversion & Co-Products (cont.)

- Thermochemical
  - apply technologies to ag-based energy
    - preprocessing (especially on-farm)
    - on-or-near-farm processing
    - help ID key feedstock/crop traits
  - co-products (e.g., agri-char)
- Process Economics;
  Market & Life Cycle (LC) Analyses
  - identify R&D goals & priorities
  - evaluate LC energy efficiencies, carbon, water
- Upfront tech transfer plans & partners
  - pilot facilities at ARS regional
  - research centers

4. Component Integration

- **Development & Production**
  - **field testing new varieties**
- **Development & Conversion**
  - **conversion testing**
  - **optimizing co-products**
- **Production & Conversion**
  - **feedstock preprocessing, pretreatment, handling, quality**
- **Cross-Component teams**
  - **Cellulosic to EtOH/BuOH**
  - **Biodiesel**
  - **Starch/sugars to EtOH/BuOH**
  - **Other fuels**

Switchgrass
Biofuel on a Big Scale

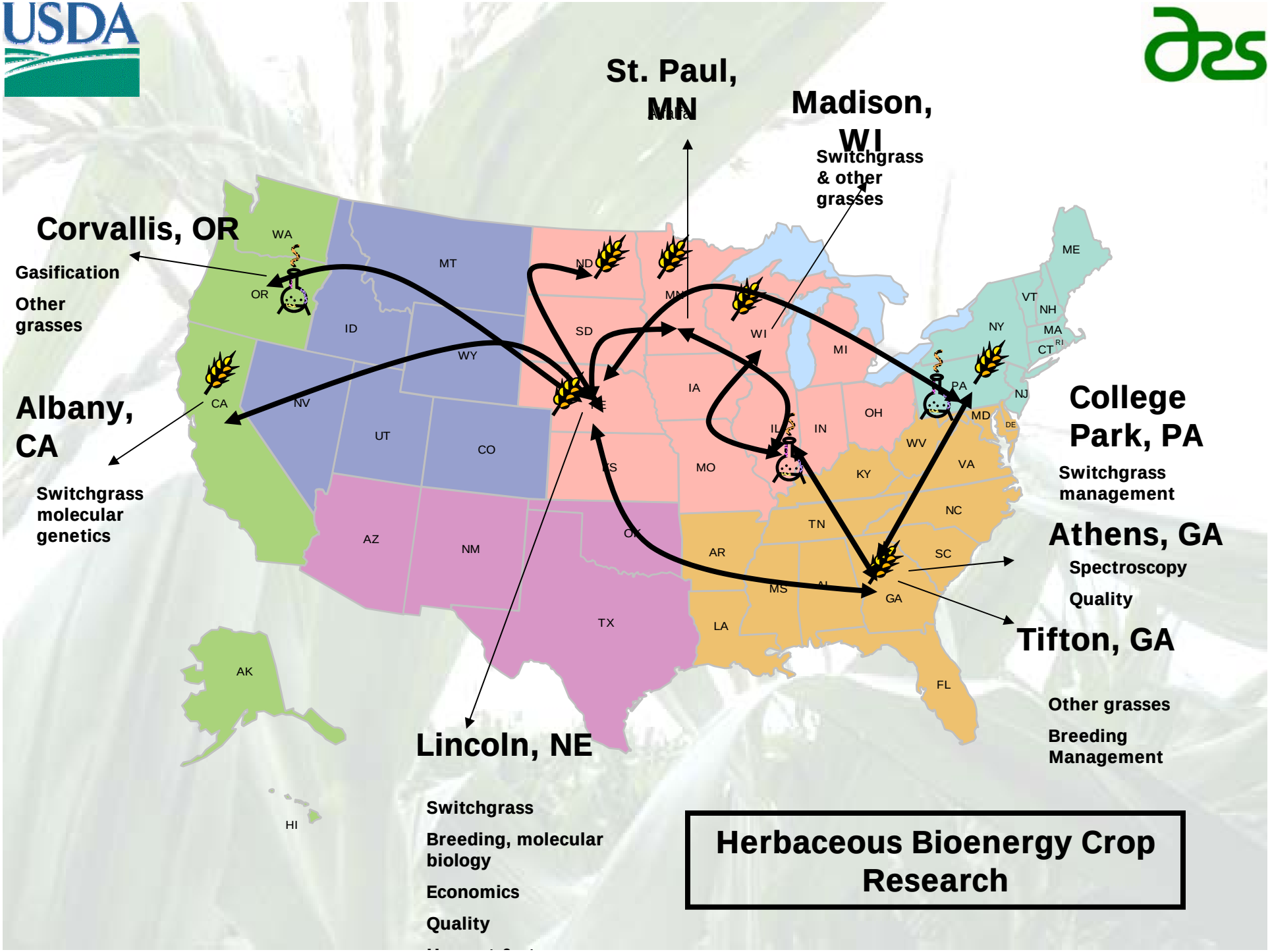
- ARS Research in Lincoln, Nebraska, determined the actual energy required to grow, transport, convert switchgrass into ethanol
- First such large-scale study - used real farmers
- Switchgrass produced 540% more renewable energy than nonrenewable energy consumed!

Beyond Corn and Soybeans

- ARS research in Wyndmoor, Pennsylvania, developed high-efficiency processes to produce ethanol from barley
- Local farmers grow winter barley as a dual use (food and fuel) cover crop
- Bonus - barley cover crop production reduces nutrient pollution in the Chesapeake

USDA / ARS
Bioenergy / Bioproducts
Research Locations

USDA


St. Paul, MN
Madison, WI
Switchgrass & other grasses
Corvallis, OR
Gasification
Other grasses
Albany, CA
Switchgrass molecular genetics
College Park, PA
Switchgrass management
Athens, GA
Spectroscopy
Quality
Tifton, GA
Other grasses
Breeding Management
Lincoln, NE
Switchgrass
Breeding, molecular biology
Economics
Quality
Herbaceous Bioenergy Crop Research
WA
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Coordination & Cooperation

Within USDA

- USDA Energy Council – Research Committee
- USDA Biobased Products & Bioenergy Coordination Council (BBCC)
- REE Agricultural Bioenergy and Bioproducts Research, Education and Economics (ABBREE) Council

With Other Departments/Agencies

- Biomass R&D Board and Technical Advisory Committee
- Regular program staff communications between ARS and DOE-EERE, DOE-OS, EPA, NSF, DoT
- Scientist exchange program with DOE (Bioenergy Research Centers, National Labs.)


Agricultural Science:
Addressing the Challenges of
Biomass Technologies with
Investment plus Serendipity
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