Perennial biomass crops on environmentally sensitive land in the US

USDA-NIFA Projects

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Photo source: Mike Collins
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Mission: Invest in and advance agricultural research, education, and investment to catalyze transformative discoveries, education, and engagement to address agricultural challenges
Sustainable Bioenergy and Bioproducts Program

**Vision:** Facilitate the development of sustainable regional production systems for biofuels, biopower, industrial chemicals, and biobased products, through partnerships and collaboration, for increased rural economic vitality, ecosystems services, and national energy security.
CAP awards support large-scale multimillion dollar projects to promote collaboration, open communication, and the exchange of information; reduce duplication of effort; and coordinate activities among individuals, institutions, states, and regions.

CAP participants serve as a team that conducts targeted research or research, education, and extension in response to emerging or priority area(s) of national need.

Coordinated Agricultural Project
AFRI Biofuel Feedstocks and Project Locations
Sustainable Production and Distribution of Bioenergy for the Central USA

CenUSA Bioenergy is supported by Agriculture and Food Research Initiative Competitive Grant No. 2011-68005-30411 from the USDA National Institute of Food and Agriculture
Our **vision** is to create a **regional system** for producing advanced transportation fuels and other bio-based products from **perennial grasses** grown on land that is either unsuitable or **marginal** for row crop production. In addition to producing **advanced biofuels**, the proposed system will improve the sustainability of existing cropping systems by **reducing agricultural runoff of nutrients and soil** and increasing carbon sequestration.
Environmental Services:
- Carbon Credits
- Improved Soil Quality
- Reduction in Nutrient Leaching

Benefits to wildlife
Perennial Biomass on Highly Erodible Land (HEL)

Opportunities to feed the world

Grain and Cover Crops

Global Impacts

Recycle Nutrients

Cellulosic Biomass

Renewable Energy

Distributed Pyrolyzers

Biochar recycles nutrients to the land, syngas powers the pyrolyzer, and bio-oil is a renewable energy raw material

Centralized Upgrading Facility

Drop-in liquid transportation fuels, bioasphalt, and fine chemicals
An illustration of competing economic drivers and limiting factors that must be balanced to achieve sustainable cellulosic feedstock supplies needed to support a transition from fossil to renewable fuels (from Wilhelm et al. 2010. Industrial Biotechnology 6: 271–87)
Why these land classes?


Source: USDA NRCS

Source: Iowa State University

Source: Purdue University
Why these crops?

- High biomass yields
- Native species
- Reduce soil erosion
- Improve soil quality
- Increase carbon sequestration
- Reduce water runoff
- Increase water infiltration
- Provide wildlife habitat
Why this region?

- Precipitation
- Soils
- Crop Consultants
- Biomass
Why fast pyrolysis?

Rapid thermal decomposition of organic compounds in the absence of oxygen to predominately produce liquid product known as bio-oil.

Bio-oil is refined like petroleum into synthetic gasoline and biodiesel.

Fast pyrolysis can be built at small scales suitable for distributed processing.

Co-product biochar is produced at yields of 12-20 wt% biomass.
Distributed Processing
Herbaceous Biomass to Value-Added Products Via Fast Pyrolysis

Pyrolyzer

Product Recovery

- Heavy Ends
- Light Ends

Biochar

Phenolic Oligomers

Sugars

Fermentation

Lipids

Lipid Fuels

Gelled Fuel

Bio-oil Co-firing Fuel

Bio-asphalt

Hydrocarbon Fuels

Fermentation Substrate

Ethanol
1. Feedstock Development
2. Sustainable Production Systems
3. Feedstock Logistics
4. System Performance
5. Feedstock Conversion
6. Markets and Distribution
7. Health and Safety
8. Education
9. Extension and Outreach
10. Commercialization
Relationship Between Surface Run-off and P Losses from Biomass Systems

Maize: 15 Events; 7021 L; 16 g P
Sorghum: 17 Events; 8690 L; 20 g P
Switchgrass: 5 Events; 1345 L; 4.7 g P
Miscanthus: 16 Events; 6911 L; 16 g P
Poplar: 16 Events; 7740 L; 5.2 g P

Purdue Throckmorton Site 2014
Modelling Water Quality

CEAP Integration

Used 3 years of detailed farm management data, NRI, soil survey, conservation plan records, 47 years of weather to populate model

131 sub-basins in UMRB

Integrated SWAT and APEX models to evaluate the effects of existing conservation practices

Which locations should we target for perennial biomass crops?

Developed tradeoffs between costs and reductions in hypoxic zone size

Conservation Effects Assessment Project (CEAP)
Enhancing Mississippi Watershed Ecosystems with Perennial Bioenergy Crops

September 23–24 | Depot-Renaissance, Minneapolis, Minnesota
Extension Agriculture and Energy professionals from 18 states attended and learned about growing perennial grasses for bioenergy.
Learn More – Visit our website

About CenUSA Bioenergy
Welcome to CenUSA Bioenergy. We are the home of an ambitious Iowa State University-based, USDA National Institute of Food and Agriculture (NIFA) sponsored, research project investigating the creation of a Midwestern sustainable biofuels and bioproducts system. This website is dedicated to sharing our work with everyone interested in a sustainable bioeconomy.

Iowa State University's Ken Moore is the project director for our eight institution network: Iowa State University, Purdue University; University of Wisconsin; University of Minnesota; University of Nebraska-Lincoln; University of Illinois; University of Vermont; USDA Agricultural Research Service. Read more

Education
Provide rich interdisciplinary training and engagement opportunities for undergraduate and graduate students in all areas of bioenergy value chain to meet the workforce challenges of the emerging economy.

Featured Video
Water Quality and Sustainable Bioenergy: Synergies for the Northeast U.S.

The NorthEast Woody/warm-season Biomass Consortium (NEWBio) is a coordinated agricultural project funded by the United States Department of Agriculture (USDA) - National Institute of Food and Agriculture (NIFA) - Agriculture and Food Research Initiative (AFRI) Competitive Grant no. 2012-68005-19703. NEWBio is a regional network of organizations dedicated to building robust, scalable, and sustainable value chains for biomass energy in the Northeastern U.S. NEWBio aims to overcome existing barriers and dramatically increase the sustainable, cost-effective supply of perennial warm-season grasses, short rotation woody crops, and winter annual energy crops while enhancing water quality, sustainable land management and other ecosystem services, and building vibrant communities.
The Chesapeake Bay is the most productive estuary in the eastern U.S., but is seriously contaminated with nutrients and sediment. Washington D.C. happens to sit on its shore. $Billions have been spent to clean it up, but agricultural runoff remains the major challenge.

Land Cover in the Chesapeake Bay Watershed

Map used by permission from Chesapeake Bay Commission
Biofuels and Water Quality: Blessing or Bane?

Maximum Nitrogen Load Changes for Biofuels

Millions of pounds per year of nitrogen delivered from the Chesapeake Bay watershed to the Bay under five modeling scenarios.

Assumptions for Alternative Scenarios:
- **Corn**: 300,000 additional acres of corn with typical levels of management practices
- **Soybeans**: 300,000 additional acres of soybeans with typical levels of management practices
- **300K Switchgrass**: 300,000 acres of switchgrass, converted primarily from hay and pastureland, with no fertilization
- **Corn with Cover Crops**: Cover crops on all existing and new (additional 300,000) corn acres and one quarter of all other row crops, watershed-wide.
- **1M Switchgrass**: 1 million acres of switchgrass, converted primarily from hay and pastureland, with no fertilization

**Source**: U.S. EPA Chesapeake Bay Program Office
Why payments for ecosystem services?

- Conversion facilities may pay less for bioenergy feedstocks than farmers need to earn.
- Excess nutrients from agriculture are damaging water quality.
- Growing switchgrass instead of corn reduces excess nitrogen and improves water quality.
- In the Chesapeake Bay watershed, payments are already being made for agricultural practices that reduce excess nitrogen.

Can paying for water quality benefits make bioenergy more profitable?
Switchgrass price needed to equal profit from corn

Our results ($101/Mg) compared with published values for different US regions
Switchgrass price with and without payment for ecosystem service (PES) of reducing N loading to the Bay

The PES could be used either to increase the price paid to the farmer (see “PLUS”) or reduce the cost to the buyer (see “MINUS”).
Stay tuned at:
www.newbio.psu.edu

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