Sun Grant/Department of Energy-
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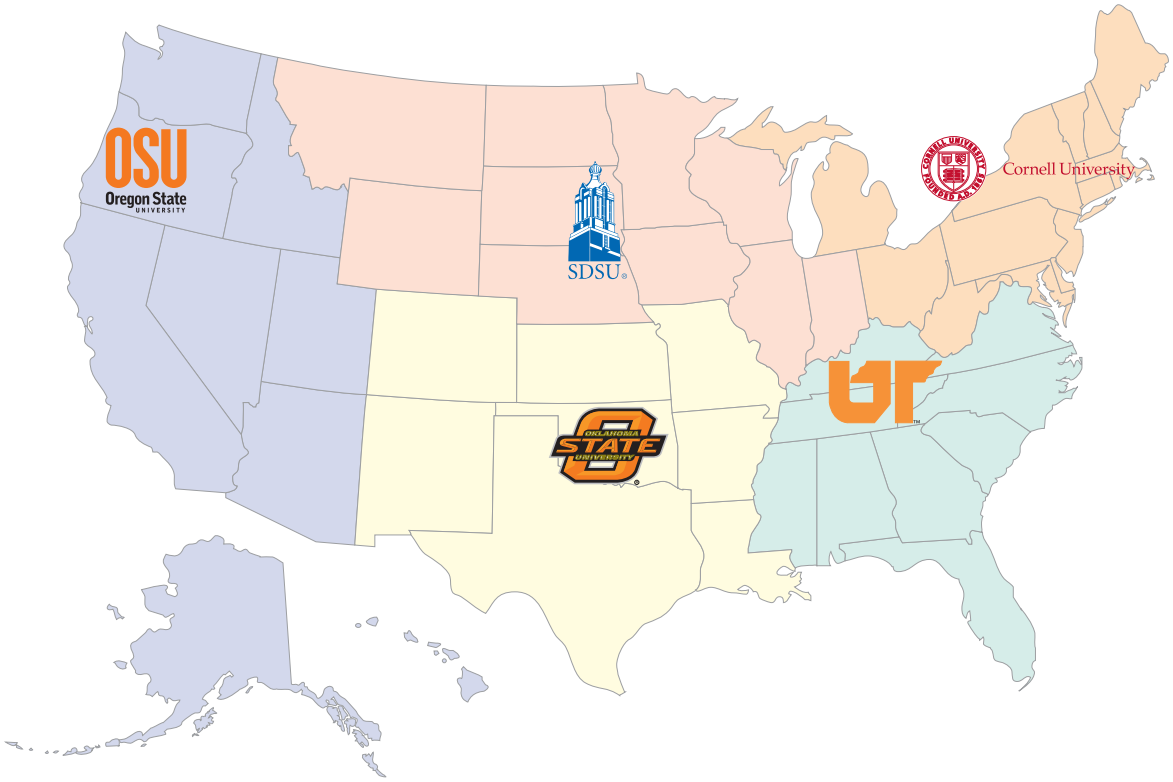

Regional Biomass Feedstock Partnership
Executive Summary

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SunGrant INITIATIVE

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The Regional Biomass Feedstock Partnership continued its work in 2010 exploring renewable sources of liquid fuels, chemicals, and power from the estimated 1.3 billion tons of cellulosic biomass that USDA/DOE analysts say could be available annually in the United States.

Formed by the U.S. Department of Energy and the Sun Grant Initiative to continue exploring the potential for a bioenergy/bioproducts industry, the Regional Biomass Feedstock Partnership now directly involves 96 scientists from universities and the U.S. Department of Agriculture's Agricultural Research Service. The Partnership is halfway through a six-year project that has included establishing 110 field trials in 39 states as well as crop modeling projects. In addition, educational/outreach work is under way to help agricultural producers, industry, and other stakeholders prepare for a future that could include processing biomass crops for energy and other products.

Assessing the Biomass Resource

The five regional Sun Grant centers in each of the Sun Grant regions around the U.S. — the Northeast, North Central, Southeast, South Central, and Western — are using geospatial analyses to probe the potential for biomass production in each region.

Research for the Northeast Sun Grant Center, based at Cornell University, concludes that in 10 of the 14 northeastern states, 3 to 20% of cropland could become available for feedstock production in 2020 while maintaining current crop production at 2007 levels. The projected total potential for feedstock production is 40 million dry tons for low intensity production or 63 million dry tons for high intensity production on potentially available cropland and herbaceous land. Achieving the projected high-intensity yield with perennial feedstocks will require substantial field research.

The North Central Sun Grant Center at South Dakota State University focused effort on understanding potential production rates of switchgrass in relation to soil, climate, and cultivation practices. Researchers conducted a meta-analysis of existing studies, reviewing 1,167 observations associated with 45 field trial locations across 16 states. They investigated the main drivers of switchgrass yields (such as climate, environmental variables, and genetic factors) across a broad geographic region. They also considered whether lowland cultivars have a distinctive climatic niche compared to upland cultivars, and they looked at inter-annual variability in switchgrass yields due to climate. Nitrogen fertilizer was the most important variable of yield, followed by cultivar, highlighting the importance of agronomic practices and genetic variability.

Another North Central Region study examined geographic patterns and inter-annual variability of crop residues, another important source of cellulosic feedstocks. Counties in the southeastern part of North Central region were observed to have a relatively high mean crop residue yield potential and the lowest inter-annual variability in crop residue yield potential. Portions of Wyoming, the eastern Dakotas, and northern Minnesota had the highest variability in crop residue yield potential.

A geospatial analysis of bioenergy options for the Southeast Sun Grant Center at the University of Tennessee has led to development of software called BIOFLAME (Biofuels Facility Location Analysis Modeling Endeavor). The model allows the user to perform an analysis on any combination of counties within a 16-state region in the southeastern United States given parameters such as biorefinery capacity, crop prices, transport cost rate, feedstock yield adjustments, hay land availability, driving distance limit, required profit, and more. BIOFLAME is a comprehensive GIS modeling system for assessing potential feedstock across a region and identifying ideal locations for biorefineries and preprocessing facilities. Significant improvements and additions have been made to BIOFLAME in 2010, the most important being the ability to site multiple facilities and multiple facility types. The model can now site up to 8 biorefineries or combinations of biorefineries and preprocessing facilities for a given scenario.

The Oklahoma State University-based South Central Sun Grant Center is developing a database on potential biomass crops including corn stover, small grain residue, energycane, sweet sorghum, CRP grasses, miscanthus, switchgrass, short-rotation willow, and short-rotation poplar. Switchgrass yields have been estimated for the top five soils for all counties in Oklahoma. The estimate of yields was performed using the switchgrass yield data collected from the research stations and comparing these yields with the yields of other crops obtained from the NRCS online sources for that particular soil

type. The current estimate of the total potential switchgrass supply for Oklahoma from the top five soils of each county is 49.5 million tons.

The Western Sun Grant Center at Oregon State University has focused on tasks such as preparing a geospatial inventory of existing biomass in the Western Region; estimating the geospatial distribution of biomass for cereal crops nationally; and developing national "wall-to-wall" crop suitability maps for important feedstocks. Researchers are developing a simple suitability/yield model that incorporates important environmental constraints on biomass production such as climate and soils. The result is high-resolution, gridded "first-guess" potential biomass maps for the conterminous United States. The maps serve as a starting point for more refined mapping.

Herbaceous Energy Crops

Herbaceous crops that are the subject of feedstock studies include switchgrass, Miscanthus, energycane, sorghum, Conservation Reserve Program land, corn stover, and cereal residue.

Switchgrass has been identified as a model herbaceous perennial feedstock because it is broadly adapted and has high yield potential on marginal croplands. The Regional Feedstock Partnership selected switchgrass as one of four herbaceous species for which replicated field trials should be established across the United States. Two key objectives of Feedstock Partnership research are to determine switchgrass production on land that may be marginal for traditional agricultural crops in different regions of the United States, and to determine the influence of nitrogen fertilizer on switchgrass production.

Field trials are under way for Miscanthus x giganteus, a warm-season, perennial grass native to Japan. First imported to the United States as a landscape ornamental, Miscanthus has become the subject of renewable energy research because it produces so much biomass compared to other crops adapted to temperate regions. It is expensive to establish, but plantings are expected to be productive for up to 15 years.

Sugarcane or energycane has tremendous potential to yield biomass. At full production, average yields range from 22 tons per acre of dry material in Louisiana to 34 tons in Florida. In comparison switchgrass yields 5-8 tons/acre and giant miscanthus yields 10-18 tons/acre in the South. Five varieties of cold-hardy sugarcane (called energy cane) are being tested at eight locations around the United States to determine the limits of their ability to grow and yield.

Data over three years show that sorghum can be highly productive as a biomass crop and that the productivity begins in the year that the crop is planted — there is no establishment year. Yield potential is highly dependent on the environment.

Conservation Reserve Program (CRP) enrollment as of October 2010 stood at approximately 30.6 million acres, mostly dedicated to grasses. In its report on the technical feasibility of a billion-ton annual biomass feedstock supply, the Department of Energy (DOE) estimates that between 17 and 28 million dry tons of biomass to be available for bioenergy production from current CRP land. The Feedstock Partnership is assessing yield potential and suitability of CRP grassland as a bioenergy feedstock source across regions of adaptation using standard agricultural practices. Biomass yield was associated with stand quality. Established stand quality was maintained or improved by delayed harvest until the end of the growing season or after the killing frost with fertilization. Nitrogen fertilization has a negative impact on persistence of legumes.

Corn stover — the leaves, stalk, husks, cob and tassel — is among the most abundant potential feedstock materials for biofuels identified in the Billion Ton study. Economic analysis has been used to quantify the nutrient replacement cost associated with harvesting corn stover. Research has also quantified the average macronutrient (nitrogen, phosphorous, and potassium) values for the 2008 and 2009 harvests. Fertilizer cost, driven primarily by oil prices, is the main factor causing the total value to fluctuate between $10 and $20 per dry ton. Planned activities for 2011 include soil, plant composition, greenhouse gas emission, and life-cycle analyses to quantify energy and carbon balance for cob harvesting systems, and an assessment of the effects of stover harvest on soil compaction properties. A commercial scale corn stover harvest case study is also under way.

Cereal residue is an important area of research because cereal grains (wheat, barley, oats, sorghum

and rice) are among the most widely grown crops in the United States. Many stakeholders have assumed that large amounts of cellulosic residue should be available from cereal crops because of the large acreage devoted to such crops. The Feedstock Partnership has attempted to catalog grain yields and use this information with harvest index values to determine possible residue yields; document the variability over time of grain yields in environments subject to major weather events; estimate the amount of residues required to maintain soil quality; and identify existing uses of cereal residues as one factor in determining the prices that would be needed to draw residues toward biofuels use. The real conclusion of the work thus far is that cereal residue harvest needs to be evaluated at the farm and small region scale where science-based decision aids can help growers and agricultural professionals in decide where, when and how to harvest residues. It may be possible to economically harvest some portions of fields on an annual basis without affecting soil quality. It may be possible to harvest all residue from a field in some specific part of a cropping system designed for it.

Woody Energy Crops

Woody energy crops under consideration include willow and poplar. The Willow Biomass Crop Sun Grant Feedstock Partnership supports a network of 22 yield trials across the Northeast and Midwest and into the Southeast. Surveys of pests and diseases have been done to identify damage from key pests present in early-, mid-, and late-season. As this database generated by the network continues to grow, predicting yields of willow biomass crops across multiple regions of the country will become much more accurate and site-specific. Data will be used to improve economic and environmental models, develop recommendations for selecting varieties for specific regions and sites, improving crop management recommendations, and providing feedback for ongoing breeding. Without this information, the deployment of willow biomass crops would encounter difficulties due the uncertainty about willow production.

The Hybrid Poplar Energy Crop Development Plan focuses on poplar as a potential biomass energy crop due its rapid growth, ease of commercial-scale propagation, ability to regrow from established root systems, potential for hybridization, and inherently high genetic diversity. Poplars are being grown commercially in Minnesota and Oregon for fiber and energy on longer harvest rotations ranging from seven to fifteen years. The stand management practices for this type of production system are well established and cost of production can be estimated fairly accurately. However, yields can be greatly improved through genetic improvement research and potentially through changes in management systems. Combining yield and production costs could provide a more complete picture of the economic feasibility of producing biomass energy through dedicated energy crops such as poplar. Through the assistance of industrial cooperators in Minnesota, a cash-flow model containing management inputs necessary to achieve optimal production on non-irrigated agricultural soils typical of those in many regions of the United States has been developed.

Education and Outreach

The Sun Grant BioWeb (http://bioweb.sungrant.org) makes information and data available online about bioenergy and bioproducts created from biomass. Created as a resource for scientific researchers, policy makers, large- and small-scale industry, agricultural producers, and others who want to learn more about biomass research, BioWeb summarizes existing research on key bioprocessing topics.

To date, BioWeb has 110 topical sections, authored by scientists at 18 different universities and colleges, one private industrial firm, and several federal agencies or laboratories. Since the public launch of the resource on April 15, 2007, the site has garnered 44,242 unique visitors and 152,514 page views. Fifty percent of these visitors originated from standard search engines while the remaining visitors came via direct links from associated websites. The top four countries of origin for visitors to BioWeb were (in order) the United States, Canada, the United Kingdom, and India. The most-viewed content areas were cellulosic ethanol technologies, dry grind corn ethanol technologies, and pyrolysis for the production of biopower. BioWeb plans for the coming year include adding a clearinghouse page for

K-12 curricula available for teachers. Another new feature of BioWeb will be a section on current issues authored by selected experts.

Funding

The North Central Regional Sun Grant Center at South Dakota State University supported research through a grant of $14,175,986 provided by the U.S. Department of Energy Office of Biomass Programs. Institutions undertaking research for the Regional Biomass Feedstock Partnership supplied cost share funds that totaled $3,543,997. That makes for a total of $17,719,983 that is currently being invested nationwide through the Partnership into research to develop new sources of renewable energy and other products from biomass. The continued progress of the Partnership as the six-year project moves forward will provide a more comprehensive suite of data and new information for understanding the potential of America's biomass feedstock supply chain.