ARS and the Regional Biomass Research Centers

In 2010, U.S. Department of Agriculture Secretary Tom Vilsack created five Regional Biomass Research Centers to help make the most of existing USDA research resources. A commitment to research is necessary to help establish a successful bioenergy industry in different parts of the country through the development of dependable supplies of feedstocks for advanced biofuels production. A regional approach to feedstock production will help enable broad participation by many rural areas across the country in the emerging biofuels and biobased-products economy.

In particular, the regional biomass centers organize USDA's Agricultural Research Service and Forest Service bioenergy research into a structure that fosters collaboration among researchers along the complete bioenergy-production continuum.

The five USDA Regional Biomass Research Centers serve to complement and coordinate ARS and Forest Service research across the country to help accelerate the establishment of commercial, region-based biofuel supply chains based on agricultural and forestry-based feedstocks. The centers are networks of existing ARS and Forest Service facilities and scientists in locations across the country.

Northern-East Regional Center: This center is coordinated by the Forest Service Research and Development and focuses on production of woody biomass for biofuels, with research directed at screening for superior traits; short-rotation woody crops; sustainable management systems, including forest health and conventional forest operations; life-cycle analysis; quantifying sustainable supply and demand; conversion of woody biomass to advanced fuels and coproducts; and design of biofuels and coproduct deployment.

Southeastern Regional Center: The highest priority research need for the Southeastern region is the development of superior performing herbaceous feedstocks: energy cane; biomass sorghum, including sweet sorghum; other subtropical/tropical perennial grasses, such as napiergrass; and purpose-grown woody biomass. There is also a need to identify the best strategies to incorporate dedicated biomass crops into existing annual row crop, pasture, agroforestry, and forest-based systems, as well as to develop long-term strategies for using perennial energy grasses to meet the needs of emerging advanced-biofuel-producing facilities in the region.

Western Regional Center: With the relatively low precipitation in much of the western United States, the Western Regional Center's feedstock research focuses on the development of new industrial oilseed crops. Oilseed crop research is conducted in conjunction with research at the Northwestern Regional Center and includes genomic modifications to optimize fatty acid genes and breed new oilseed cultivars, characterizations of germplasm collections to identify new feedstock types, and population phenotyping. New cropping systems are needed that fit specific local and regional niches for available resources and economic development, especially under limited water availability. Woody biomass research efforts include management and use of invasive eastern red cedar, pinion pine, and western juniper to restore degraded rangelands; use of insect-, fire-, or disease-killed wood and areas at high risk of damage or loss; sustainable productivity and residue removal; economics of in-woods pyrolysis and biochar and assessment of ecological outcomes; and the logistics and costs of handling and transportation.

Northwestern Regional Center: This center's oilseed crop efforts are coordinated with those of the Western Regional Center, with an emphasis on integrating expanded oilseed production and minimizing its impact on existing wheat-based production systems. The center is also focused on restoration of western rangelands through harvest and removal of invasive western juniper and pinion pine trees. The woody biomass emphasis is on wood utilization; poplar genomics, genetics, and short rotation management; forest resource supply and characterization; production

As part of its regional approach to developing bioenergy crops, ARS is working on ways to increase the energy potential of sugarcane, from improving its genetics to growing it sustainably under various management plans on plantations from Louisiana to Hawaii.

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ARS scientists have been studying switchgrass for decades to determine if it is a viable feedstock for bioenergy production.

standards for sustainable forest management systems; alternative energy policy evaluation; and economic feasibility of feedstock supply alternatives.

Central-East Regional Center: For this center, the main research focus is on the development of perennial grasses and biomass sorghum, along with significant coordination of research on corn grain ethanol and corn stover cellulosic biomass. Emphasis is on integrating dedicated feedstock production into central-eastern agricultural production systems to enhance water and air quality and to minimize the adverse affects of bioenergy on existing agricultural markets.

As with all of the other centers, there is an emphasis on the need to increase system efficiency through introduction of nitrogen-fixing plants such as alfalfa and other legumes. Integration of perennial grass feedstocks into these systems may be a way to help reduce nutrient escape from fields to surface and ground waters and to reduce greenhouse gas emissions and increase carbon sequestration.

Geneticist Ken Vogel at the ARS Grain, Forage, and Bioenergy Research Unit in Lincoln, Nebraska, who also serves as coordinator for the Central-East Regional Center, is no stranger to bioenergy research.

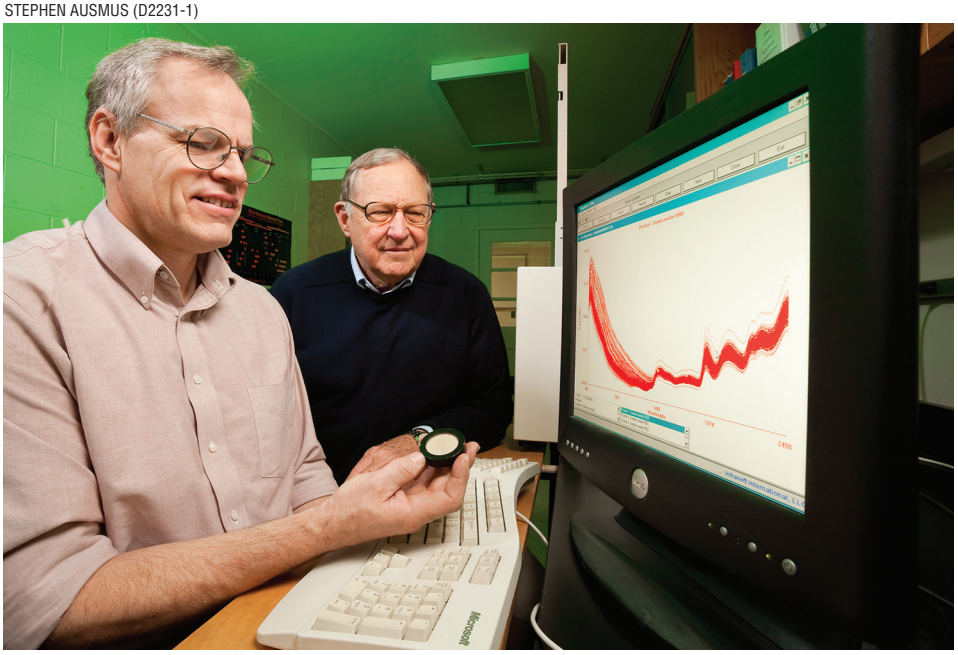
When Vogel started his switchgrass research in the 1970s, he focused on improving both the quality of livestock forages and the establishment of forages on pastures. But by 1990, he began developing switchgrass as a biomass energy crop, sparked in part by interest and support from the U.S. Department of Energy (DOE).

"Switchgrass was already being grown on land that was part of the Conservation Reserve Program [CRP], and farmers were receiving CRP payments, but the land was not producing any marketable products and new revenue," says Vogel. "I wanted to see if we could grow a crop on CRP land that would generate income and address U.S. energy needs."

Vogel worked with Oak Ridge National Laboratory staff on a series of interagency agreements that provided funding for developing switchgrass into a biomass energy crop for the Central Great Plains and the Midwest. After the initial DOE funding ended in 2002, USDA continued its support of the research.

In the initial studies, Vogel and his colleagues established a test plot in each of three states—Indiana, Iowa, and Nebraska—to evaluate almost all the available cultivars and elite strains of switchgrass. Their results showed that it was possible to develop switchgrass cultivars with high biomass yields that could be successfully grown across a broad geographic region. They also found that existing switchgrass cultivars developed for forage had the potential to produce biomass that could yield more than 500 gallons of ethanol per acre.

STEPHEN AUSMUS (D2231-1)



Geneticist Ken Vogel (background) and technician Steven Masterson examine near-infrared reflectance spectral profiles of switchgrass samples. Vogel worked with a team of ARS scientists to develop the first near-infrared sensing method for measuring 20 switchgrass components—including cell wall sugars, soluble sugars, and lignin—which can be used to determine the potential yield of cellulosic ethanol from switchgrass biofeedstock.

Vogel's team evaluated switchgrass germplasm from Midwest prairies and identified cultivars and germplasm with the most promising traits for bioenergy. Then they used that information to conduct genetic studies to obtain information for improving breeding methods and developing hybrid cultivars, including the first molecular genetic studies on switchgrass.

Results from a later, 5-year, multistate, on-farm study demonstrated that the amount of energy contained in cellulosic ethanol produced from switchgrass was five times greater than the amount of energy needed to grow, harvest, and process the crop into cellulosic ethanol. In addition, the greenhouse gas emissions from producing cellulosic ethanol from switchgrass were 94 percent lower than estimated greenhouse gas emissions from gasoline production. Assuming that switchgrass could be produced for $50 per ton with a conversion efficiency of 80 to 90 gallons per ton of feedstock, Vogel's team estimated the farmgate production costs of cellulosic ethanol from switchgrass would be about $0.55 to $0.62 per gallon.

The Central-East team also developed the first near-infrared sensing (NIRS) method to measure 20 components in switchgrass—including cell wall sugars, soluble sugars, and lignin—that determine its potential value as a biofuel feedstock. Using NIRS, they tested switchgrass varieties and experimental lines and found significant differences in the amount of ethanol that can be produced using current technologies and the amount that could be produced when technology is available for commercial-scale conversion of the plant sugars. This was calculated as actual and potential ethanol yield per ton and per acre. Results indicated that NIRS could estimate ethanol yields of switchgrass for about $5 a sample; other methods cost anywhere from $300 to $2,000 per sample.

Other research at Lincoln has resulted in new information on how switchgrass and ethanol yields are affected by nitrogen fertility, harvest management, herbicide tolerance, stand establishment, and mycorrhizae—organisms in the soil that mediate nutrient and water uptake. Vogel's team has used this information to develop a basic set of management guidelines and cultivars for large-scale production of switchgrass as a biomass energy crop in the Central Great Plains and the Midwest.

"It's satisfying to see lots of people working on switchgrass as a bioenergy crop," Vogel says. "We're getting much closer to the point where it will be a viable feedstock that helps meet our energy needs."—By **Ann Perry** and **J. Kim Kaplan,** ARS.

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The ARS locations included in this story are part of USDA's Regional Biomass Research Centers (RBRC) network. The RBRC is made up of five national centers whose mission is to help accelerate the establishment and production of sustainable commercial biomass from farms and forests without disrupting the production and marketing of food, feed, and fiber.