Power 'Plants'
Great Plains Institute
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Power 'Plants': Native Grass Utilization Project

Goal: To research and develop models of economically viable ethanol and products production from native prairie grasses, thereby providing new revenue potential in arid regions and dramatically improving the environmental benefits of ethanol production.

Summary: Project partners seek to identify:

- regions best suited to profitable production of native grasses
- production potential and feedstock characteristics of switchgrass monocultures and native warm-season mixtures (big bluestem, indiangrass and switchgrass)
- agronomic best management practices
- changes in aggregate soil health, carbon sequestration and wildlife habitat
- revenue-generating potential from sales or grass-seed and enhanced on-farm recreational opportunity through increased habitat.
- Technical and economic feasibility of producing ethanol and chemical co-products

Background: The Great Plains is often cited as the preeminent location to test and develop the bio-fuels industry. With vast agricultural resources and infrastructure, rural communities exploring new development opportunities and a strong regional transport sector, there is arguably no better location to further liquid bio-fuels. The production of native grasses may allow producers in more arid soils--where growing corn is simply not sustainable and commodity prices are low--to enter the bio-fuels and products industry in a profitable way, and thereby stimulating much needed rural economic development. By accounting for additional revenue streams through carbon sequestration credits, seed harvesting, and recreational opportunities like hunting and birding, we hope to highlight real-world opportunities for producers to enhance their income. By looking at potential uses for marginal soils, opportunities to increase native flora and biodiversity, limiting inputs and waste streams; and finding ways to improve overall soil, water and air quality; this project aims to support the a future fuel and products industry that is environmentally sound from farm to fuel tank.

Scope: Western Minnesota, eastern North and South Dakota **Timeframe:** 2002-2005

Primary Partners:
The Great Plains Institute for Sustainable Development is a 501 (C) 3 non-profit organization whose mission is to improve the economic, environmental and social health of the northern plains by, among other things, catalyzing pilot demonstrations of promising technologies and conducting research towards commercialization for such technologies. One of the Institute's core competencies is facilitating and managing large, cross-disciplinary, multi-interest projects. Institute staff have considerable experience in facilitating and managing diverse, high-level groups toward common purpose. Institute staff manage all aspects of the research and involve stakeholders from around the region who collectively aim to implement policy and project recommendations based on the outcomes of this research and aimed at building a bio-refining industry in the northern plains.

South Dakota State University Personnel at SDSU have over 35 years combined experience working with forage crops, native grasses, and introduced grasses in the semiarid northern Great Plains. Among other topics, biomass research at SDSU has focused on cultivar evaluation, selection and breeding of switchgrass cultivars, management of native grasses grown alone or in mixtures, conversion of CRP land to biomass energy production, carbon sequestration, soil quality, and wildlife habitat quality.

Energy and Environmental Research Center (EERC) – EERC is a contract-funded branch of the University of North Dakota with a staff of about 270 scientists and engineers. EERC process chemists have experience in developing catalytic fuel processing technologies based on both fossil and renewable feedstocks. In partnership with Ensyn Renewables, Inc., EERC is working to develop a biorefinery concept based on fast-pyrolysis conversion of switchgrass to a bio-oil, from which components are extracted for conversion to ethanol and non-fuel products. The concept is based on the Ensyn-developed fast pyrolysis process, which is commercially employed today at four plants in Wisconsin. A key technology component of the Ensyn–EERC biorefinery concept is an EERC-developed catalytic process that enables continuous (as opposed to batch) hydrolysis of levoglucosan and other bio-oil-contained anhydrosugars to fermentable sugars. In work with an anhydrosugar-rich Ensyn bio-oil fraction, the process has been demonstrated to achieve near-100% conversions of levoglucosan to glucose and other fermentable sugars.

Status of Research: Key findings

AGRONOMY:

Methodology: Several experiments were designed to: (1) identify the best available switchgrass cultivars and harvest management schemes for sustainable biomass production, (2) evaluate the most promising germplasms for developing new high-biomass-producing cultivars of switchgrass for the northern Great Plains, (3) determine best management practices (harvest timing, harvest frequency, fertility) for production and persistence of established switchgrass monocultures and native grass mixtures, (4) directly compare production and persistence potential of monocultures versus mixtures in a late fall harvest management system, (5) evaluate the impact of biomass harvest management systems on soil quality and carbon storage, and (6) assess the impact of harvest management and plant species diversity on avian wildlife species.

Accomplishments/Status:

- **Over a four year period, bi-annual harvests yields are similar to annual harvests.**
- **Harvest timing is critical to stand longevity.** Persistence of switchgrass and other native grasses is negatively affected when harvested at anthesis on a yearly basis, while harvesting after a killing frost seems to have little or no deleterious effect.
- **Switchgrass has potential for bio-fuels as far west as the 100th meridian** in the northern Great Plains, but profitable biomass production is highly dependent on spring (April-May) precipitation.
- **Although cultivars from northern origins** (i.e., North and South Dakota) have lower biomass production potential than cultivars form southern origins (i.e., Nebraska, Oklahoma, Illinois) in the short term (i.e., 1-2 years), their superior hardiness and persistence enable them to sustain high levels of biomass production for many years in the northern Great Plains.
- **Switchgrass grown as a bioenergy crop** on CRP land maintains or minimizes changes in soil quality and carbon storage. When grown on conventional cropland, switchgrass production improves soil quality and carbon storage.
- **The greater the diversity of grasses** and stand height, the greater the density and diversity of nesting song-birds, based on studies done on CRP, cropland, and native prairie by wildlife biologists. This is particularly important since hunting and birding are becoming significant sources of new revenue for some landowners.
- **Mixtures may provide better ground coverage to** reduce channeling and the associated water erosion and soil run-off. Big bluestem and other native grasses spread more readily into open areas providing much needed cover on some marginal land.

FUEL PROCESSING:

Methodology: Using selected feedstocks and the Ensyn 10-pound-per-hour pyrolysis reactor system, Ensyn will develop an optimized fast pyrolysis process and use the process to generate samples of whole and fractionated bio-oils, which will be delivered to EERC for characterization and evaluation as feedstocks for production of ethanol and other products. EERC will evaluate bio-oil samples based on yield of fermentable sugars and conversion of fermentable sugars to ethanol, and yield of selected non-fuel products, including alkanolamines.

Accomplishments/Status:

- **First feedstock was sent through bio-oil reactor in early October of 2004.** Bio-oil yields of about 65% were achieved. Because the bio-oil produced in these initial tests contained lower-than-expected levels of levoglucosan and other desired pyrolysis products, a water quench will be added to the reactor system to effect faster product condensation, which should reduce the occurrence of undesirable secondary reactions, and increase levoglucosan yields.
- **With the new reactor system**, processing of switchgrass and Big Bluestem is slated for early February.
- **Optimizing a bio-oil process for other high-value chemicals will improve overall plant economics** A key potential bio-oil-based product platform is the alkanolamines. In 2001 an estimated 3.3 billion pounds of alkanolamines were used worldwide. At 2000 prices of about $1.50–1.80 per pound, this represents an annual market of at least $5 billion.

Technical challenges encountered:

- **Grasses have higher ash and potassium content** by comparison to wood (which the bio-oil system is built upon). The fall harvested grasses have shown approximately 5-7% ash, whereas wood traditionally has about 0.5% ash content. The potassium in the ash causes undesirable catalytic reactions in the bio-oil processing system that lead to chemical breakdown beyond that targeted. Research partners are characterizing ash on early spring harvest samples to determine if there is a significant reduction in Potassium due to further translocation within the plant and leaching into the soil from precipitation activity.

ECONOMIC and POLICY IMPLICATIONS of RESEARCH:

- **Economic analysis underway** in partnership with the University of Minnesota's Applied Economics Department. Total production costs were evaluated for several counties with high CRP enrollment in the region. A transportation model was developed to predict the cost per ton of hauling the grass from dispersed plots to a central plant within a 50 mile radius. Research partners are just starting to assess the process economics based on the Ensyn system.

- **Early policy recommendations included modifications to USDA conservation management practices** to foster soil and wetlands-based carbon sequestration (official comments accepted and incorporated into new NRCS management practices).

- **Analysis underway on the extension and modification of Conservation Reserve Program** to ensure that regional land in contracts ready to expire in 2006 and 2007 are renewed and to refine rules for biomass harvest and sale that is consistent with ecological intent of program.

- **Anticipated recommendations for broader incentive packages and other policy tools** that would help alleviate greater capital costs, incent production and stimulate market demand for the fuel expected to be rolled out in the spring of 05**.**