

## **POWELL RIVER PROJECT**

### *Request for Project Renewal*

## **Herbaceous Crops for a Biofuels/Bioproducts Industry on Reclaimed Mine Lands**

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### Summary

In 2007, we began a project to investigate yield capacity of several feedstock species with potential suitability for revegetating mined land. Seeded species included panicgrass, switchgrass, a 1:1 seed mix of panic- and switchgrasses, and two species established from vegetative propagules: hardy sugarcane and miscanthus. Plants were established at the Powell River Project Research and Education Center on 30 May 2007 and stand survival and plant measures were taken 4 October 2007. A single biomass harvest was taken 11 January 2008, and estimates of frost heaving were made at that time as well. Of the plant species tested, hardy sugarcane had the greatest stand success (97% survival) and sugarcane plants were the most robust as measured by plant size. Biomass yields of the larger, vegetatively propagated species (Miscanthus and sugarcane) were limited by the number of plants established within a plot (100). Although panicgrass and switchgrass were smaller in size, establishment by seed conveyed a yield advantage because plants were well-distributed across the plots. Drought conditions limited growth of all plants (based on crop performance at other research sites) and may have contributed to susceptibility to frost heaving for smaller plants (panic- and switchgrasses) on wet, poorly drained sites. Although sugarcane appeared the best plant for establishment under the difficult conditions of 2007, preliminary observations in March 2008 suggest it may not have survived the winter.

This request seeks renewed funding to monitor plant growth and morphological characteristics and feedstock quality of plants grown on mined soils. Funds have been obtained from other sources to perform identical field trials at 3 other locations throughout the state. Renewed funding will meet Powell River Project objectives of helping find new uses for mined lands.

**Funding requested: \$3,630 in Year 2 (\$10,513 total over 3 years).**

**Matching funds: \$19,000 requested for three additional research sites**

## **I. Introduction:**

Growing interest in the potential to produce “green power” and bio-based products from biorefineries is spurring research efforts in biofuels production. This interest is driven by three key issues: 1) fossil fuel supplies are finite, thus current energy use patterns are not sustainable in the face of existing demand; 2) reliance on foreign energy supplies puts the US at risk; and 3) fossil fuel consumption has potential negative environmental consequences.

Biorenewable industries that generate fuels and chemicals from biomass will be one part of the solution to humanity’s energy and product needs. These systems may be foundational for an agricultural revival of rural economies. Few other new agricultural enterprises have the potential for such broad-scale impact as biorenewables industries because of their large land requirements.

Yield per land area will be an important determinant for economic viability of a biomass-to-biorenewables industry. Because raw biomass will be a low-value commodity (in dollars per ton), yield must be sufficient to warrant producer adoption and market entry. And, because delivery costs decline with increased yield per land area, a process facility will want certainty that sufficient supply can be grown close at hand. Thus, as a first step in bringing this green industry vision to reality, both producers and manufacturers must know the productive potential and feedstock characteristics of potential biomass resources, or feedstocks.

Development of biofuel systems may be further abetted by imposition of carbon emission policies which promote reductions in greenhouse gases. Potentially, such policies would allow carbon emitters to pay farmers for the carbon that is sequestered in soils due to their production practices. Thus, biomass producers would stand to profit by growing low-input, perennial crops with large root systems that “sink” ample amounts of carbon in the soil. Using reclaimed mine lands to this end is thus especially intriguing, because if high-yielding feedstocks with substantial carbon sequestration capacity can be suitably productive on these marginal sites, the region may continue to benefit from its ability to supply energy feedstock.

This experiment is testing well-known and novel feedstock crops on reclaimed mine lands at the Powell River Project. Testing is also occurring at three additional sites in Virginia. In addition to testing feedstock quantity and quality, the study also is examining the ability of these species to sequester carbon in the soil. Data from this study will provide growers and industry with needed information to support the development of this exciting new agriculture-based enterprise.

## **II. Objectives:**

1. Evaluate and compare stand establishment of five potential biofuel/bioprodut crops (switchgrass, coastal panicgrass, miscanthus, giant reed, and hardy sugarcane) on reclaimed mine lands in Southwest Virginia.
2. Evaluate these crops for growth traits such as plant height, crown width, tiller number, lodging, and leaf:stem ratio that relate to yield and feedstock quality.
3. Quantify yields in the establishment year and succeeding years.

4. Examine feedstock quality (cellulose, hemicellulose, lignin, nitrogen, and ash) of these potential biomass crops.
5. Determine the carbon sequestration potential of these biomass crops.

### **III. Methods and Procedures:**

#### **Plant species:**

Switchgrass, coastal panicgrass, and a 1:1 mixture of these species were seeded into plots with a plot seeder on 30 May 2007. At the same time, 100 plants/plot were established for both miscanthus and hardy sugarcane.

#### **Sites:**

In addition to the Powell River Project, plots were established at the Northern Piedmont Agricultural Research and Extension Center (AREC; Orange, VA), the Southern Piedmont AREC (Blackstone, VA) and the Southwest Virginia AREC (Glade Spring, VA).

#### **Measurements:**

Plant growth measurements such as plant height, crown width, and tiller number will be made prior to the first harvest each season.

For yield and quality estimates, a portion of each plot will be harvested according to the following schedule:

- Late fall: about 1 month after killing frost (late November)
- Early winter (January)
- Late winter (February or March)

Three estimates over time will be obtained, because dry matter concentrations and feedstock quality change with weathering.

A plot harvester will be used for yield samples in switchgrass and panicgrass stands. For the taller plant materials, a forage chopper will be used to harvest the biomass, and the collection vehicle will be weighed with load cells. The harvested biomass will be sub-sampled and assayed for key chemical constituents – cellulose, hemicellulose, lignin, ash, and nitrogen – as measures of biofuel and biorefinery feedstock quality. Evaluations will be conducted for a minimum of three years – the establishment year and two subsequent growing seasons.

Soil samples from each plot will be collected to 1-meter depth prior to establishing experimental plots. Soil cores will be divided and analyzed for carbon in the upper 8 inches and the remaining will be assayed on these samples for baseline determination. At the end of the third year, these sites will be assayed again to determine change in total soil carbon and to determine the contribution of each species to their respective soil carbon pools. Carbon values will be used to determine the potential of these crops both to produce biofuels and to remove carbon from the atmosphere. Measured values of soil carbon will be compared to control plots to demonstrate sequestration effectiveness.

### **IV. Benefits:**

This project has excellent fit with the PRP mission. The research conducted will determine suitability of several potential biofuel species for mined land restoration. In addition, these plant species may offer opportunity to produce low-input cash crops with substantial carbon

sequestration capability. Such biofuel plants could reward growers and landowners while supporting a nascent green products industry.

**V. Schedule:**

Plots were established in June, 2007 and soils have been sampled and are near completion for background carbon data. Plant growth measures were taken in October and yield samples were collected in January. In 2008, growth measures will be taken routinely through the summer and yields will be determined at fall, winter, and late winter harvest dates

**VI. Deliverables:**

Data from this research will be provided to PRP in the form of progress and final reports. Extension and Common Press publications as well as presentations on site are anticipated in order to extend awareness to the general public. Journal manuscripts are a key component to pushing back the frontiers of science. Publication in journals such as Crop Science, Agronomy Journal, or Biomass and Bioenergy is anticipated and will be vital to disseminating these results to the scientific community.

**VII. Multiple year project:**

This project needs to be conducted for at least three years. Bioenergy stands will not achieve production maturity until two or (based on our initial observations) more probably three years of age. This also is a minimum time to obtain soil carbon sequestration accretion.

**VIII. Brief progress report:**

Most objectives for the research in year 1 have been met, and we are requesting continuation for the second year of funding. We have collected measures of plant traits and biomass yields, are near completion of soil carbon analysis and will complete initial biomass characterization soon. We did not take planned measures of leaf:stem ratio or multiple harvests over time during this first year because the persistent drought limited growth and there was little to sample.

Hardy sugarcane plants (Table 1) were the largest, and most vigorous of the biomass plantings, being about 30% taller than miscanthus plants. Stems size and tiller numbers were also much greater than for any other planting. Despite persistent drought, stand percent was greatest among all crops as of October 2007. Winter survival may be the biggest issue to the success of these plants.

<b>Species</b>	<b>Height (m)</b>	<b>Stem diameter (mm)</b>	<b>Tiller no.</b>	<b>Stand (%)*</b>	<b>Frost heaved (%)</b>	<b>Yield (kg/ha)</b>
<b>Panicgrass</b>	0.44	1.85	3.2	70	38.2	129
<b>Switchgrass</b>	0.50	1.90	3.0	81	11.5	139
<b>Mix**</b>	0.38	1.52	2.5	76	30.9	83
<b>H. sugarcane</b>	0.66	4.27	10.8	97	0	66
<b>Miscanthus</b>	0.51	2.71	3.0	81	0	15

\*Reflects cover in seeded plots or percent survival of 100 vegetatively established plants  
 \*\*Mix = Panic + Switchgrass (1:1 seeding)

Miscanthus plants survived reasonably well given growing season limitations. Establishment success rates were lower at other sites where weed pressure was greater. Observation suggests miscanthus is quite drought tolerant once established, but it is sensitive to drought during the establishment phase.

One large issue for the miscanthus plants we established: The plants we established were not *M. × Giganteus*. We were misinformed about the genetics of what we planted, and after consultation with others with Miscanthus experience, we tested the source material in our study. Flow cytology suggests that we have planted a large form of *M. sinensis*. A commercial grower is now producing sufficient *M. × Giganteus* for us to make replacements this spring.

Despite smaller plant sizes and lackluster establishment, panic and switchgrasses produced greater amounts of biomass on a land area basis due to their distribution across the plot. However, mortality rates due to frost heaving appeared to be quite high in Rep 1, thus these plots were overseeded with un-stratified seed in March 2008.

A student has been lined up to work on this and other biofuels projects through the coming year. We are meeting our objectives and excited to learn more about the potential of these species to produce biofuels on reclaimed lands.

#### IX. Funding:

<b>Item</b>	<b>Description</b>	<b>'07-'08</b>	<b>'08-'09</b>	<b>'09-'10</b>
Student labor	200 hr/year @ \$8.50/hr	\$1,700	\$1,700	\$1,700
Fringe benefits	8.5%	\$145	\$145	\$145
Biomass quality analyses	\$14.00/sample X 45 samples	\$630	\$630	\$630
Soil carbon analyses	\$25.00/sample X 15 samples	\$375		\$375
Travel & hauling	~1200 mi @ \$0.40/mi	\$480	\$480	\$480
Materials & supplies		\$300	\$300	\$300
<b>Annual Cost</b>		<b>\$3,630</b>	<b>\$3,255</b>	<b>\$3,630</b>
<b>Total Cost</b>		<b>\$10,514</b>		

Additional research funds for the other sites have been obtained from the Virginia Agricultural Council.