2013 NEWBio Bioenergy Symposium

Research Poster Descriptions

The symposium was organized by Penn State Extension and the USDA-NIFA sponsored NEWBio Bioenergy Consortium, a partnership of universities, businesses, and research labs working together to build the sustainable bioenergy industry in the Northeast US.

Poster #	S1
Name	Aponte, Rachel
Affiliation	Delaware State University
Title	Bioenergy Feedstock Production: Challenges and Opportunities
Abstract	Bioenergy involves the production of various fuel types from organisms, also referred to as feedstocks. The problems that arise with the use of fossil fuels to supply energy, such as greenhouse gas emissions or due to the envitable loss of resources, has caused scientists to look into a more sustainable means for providing energy. Bioenergy is a means worth exploring. The composition of various feedstocks will determine the fuel type that will be produced. The production of bioethanol through the hydrolysis of polysaccharides to monosaccharides and transforming the simple sugar molecules into alcohol through fermentation requires feedstocks rich in cellulose, starch, or sugar. Biodiesel is generated through the transesterification of triglycerides (oil) to obtain fatty acid esters and therefore, lipid-rich biomass is required as a feedstock. Organic waste materials like animal manure and plant residues can be used to generate biogas (mainly methane) via anaerobic digestion. Syngas from gasification or bio-oil from pyrolysis requires woody materials because the vegetative feedstock is low in mineral ash content. While many feedstocks seem to be promising, there are many challenges that prevent bioenergy from being the prominent fuel source and many scientists today are looking into solutions to improve the overall production and enhance the possibility of its use. Lignocellulosic biomass, for example, seems to be one of the most effective feedstock solutions but they require more processing due to the lignin that blocks the cellulose and hemicellulose, and then they must be converted further with enzymes. By understanding the processes of feedstock production, including its challenges and opportunities of each type, scientists can move towards a more sustainable and reliant source of energy.

Poster #	S2
Name	Buhain, Jeremy
Affiliation	New Jersey Institute of Technology
Title	Production of Biodiesel from Fresh Vegetable Oil and Waste Frying Oil

Abstract	Biodiesel production procedures can change based on the feedstock used. Biodiesel feedstocks include vegetable oils and waste frying oils, which contain triglycerides that are needed to make biodiesel. Biodiesel was produced in the lab through the transesterification reaction, in which vegetable oil and waste frying oil were separately reacted with methanol in the presence of an alkali catalyst (sodium methoxide) to form methyl esters (biodiesel) and glycerol. The high fatty acid content of waste frying oils created a problem in the process. Fatty acids in waste frying oils reacted with the alkali catalyst to form soap and water, which inhibit separation and purification of the biodiesel; thus, an esterification pretreatment with an acid catalyst (sulfuric acid, 98%) was conducted on waste frying oils to get rid of the inhibitory fatty acids. It was observed in the lab that this pretreatment was necessary in order to easily and successfully purify the biodiesel. The biodiesel yield from pretreated waste frying oil and fresh vegetable oil were similar at 81.3% and 82%, respectively.

Poster #	S3
Name	Bush, Charles, C
Affiliation	SUNY-ESF
Title	Tracking short rotation woody crop (SRWC) planting operations in northern New York
Abstract	Short rotation woody crop (SRWC) production is a new and evolving system within the Northeast and Midwest United States. The Biomass Crop Assistance Project (BCAP) provides a unique opportunity for over 240 ha of commercial scale operations to be observed and recorded so this evolving system can improve over time. Using GPS devices to track movements of two different planters (Step and Egedal), along with field observations and supply stock sampling, we determined planting rates and identified factors which contribute to planting delays. A random sampling protocol was developed for inventorying recently planted fields and records the number of living plants and cuttings lying on the ground in a subsample of plots. The average effective field capacity for the two models of planters combined was 1.34 ha hr-1, with the Step planter being slightly faster (1.43 ha hr-1) than the Egedal (1.12 ha hr-1). The median value for the two planters was much closer (Step: 1.41 ha hr-1; Egedal: 1.30 ha hr-1). Delay time accounts for 47% of the total study period, 79:46:47. Observations of planting operations also concluded that site conditions, mechanical condition of planters, availability of spare parts, experience with planters and planting stock quality influence effective field capacity and planting efficiency in SRWC systems. Density summaries are not available due to time constraints, however this study is ongoing.

Poster #	S4
Name	Fabio, Eric
Affiliation	Cornell University
Title	Evaluation of biomass yield and harvesting systems in a small-scale shrub willow plantation

Abstract	Since shrub willow is a perennial crop that is harvested more than 7 times on a 2-4 year rotation, optimization of crop management is vital. Cropping in pure stands of a single cultivar presents a potential risk from pest and disease management standpoint, but growing in polycultures could reduce that risk. Non-destructive measurements in years between harvests can be useful in monitoring growth and predicting future yield. Since harvesting represents one-third of total production costs, matching the best harvesting system with the production potential of a plantation is important economically. We used a small-scale shrub willow plantation to answer the following questions: 1) How does growth and yield in pure stands compare to random mixtures of commercial cultivars? 2) What non-destructive estimates of biomass best predict harvested yield? 3) How do mechanical harvesting systems compare to each other and to hand-harvesting? Analysis of non-destructive measures indicated that there is no significant loss of growth in mixtures compared to pure stands. Stem area in the year of the harvest was the best predictor of harvest yield, while height explained the least amount of variability in yield. There was a 10-fold difference in machine harvesting rates between the two-row New Holland FX 45 harvester with Coppice Resources Ltd. header and the Ny Vraa JF 192 single-row harvester. The yield estimates from the two machine harvests were between 24 and 33% lower than that of the hand harvest, which may be an indication of the amount material left on the field, since the hand harvest represents a near total recovery of all harvestable biomass. There are large differences in capital investment and fuel usage between the two harvesting systems, which should be taken into account, especially in small-scale production.

Poster #	S5
Name	Forgeng, Barry
Affiliation	Penn State
Title	Assessing Current Biomass Energy Market Conditions
Abstract	The aim of this project was to 1) work with extension partners to develop enterprise budgets for the establishment of three bio-energy crops (switchgrass, miscanthus, and willow), 2) investigate the reason why bio-energy crops are not offered USDA insurance, and 3) look into biomass price reporting throughout the country in order to get an idea of the perceived value of these crops. The purpose of this effort is to develop the biomass market, provide reliable and relevant data for prospective farmers, and to spur interest in biomass energy in general.

Poster #	S6
Name	Hartley, Damon
Affiliation	West Virginia University
Title	Optimization of Biomass Allocation and Facility Location in the Northeastern United States

Abstract	In the Northeastern United States, as in many places around the country, interest has developed in the increased use of renewable resources for the production of energy. While regions such as the Southwest and central have focused on the development of solar and wind technologies; these technologies have limitations on their effectiveness. In the Northeast, biomass derived from forests and short rotation woody crops (SRWC), may hold the key for renewable energy production in the region. While woody biomass is a potential feedstock for a diverse set of energy development options, little emphasis has been placed on developing supply chains to efficiently deliver the resource to the end user. Developing efficient supply chains is predicated on identifying configurations that will optimize the harvest, extraction, transport, storage and preprocessing of the woody biomass resources to provide the lowest possible delivered price. The characteristics of woody biomass, such as spatial distribution and low bulk density, tend to make collection and transport difficult as compared to traditional energy sources. These factors, as well as others, have an adverse effect on the cost of the feedstock. The objective of this research is to identify potential supply chain alternatives, through the use of mathematical modeling and computer simulations, that will potentially be able to provide sufficient quantities of biomass resources that can be utilized in the production of renewable energy at an economical price.

Poster #	S7
Name	Heil, Nichole L.
Affiliation	Penn State
Title	Highlighting the Bioenergy Market with Champions of Biomass
Abstract	One of the issues the bioenergy industry faces is lack of knowledge about local opportunities. This research aims to highlight local users and producers of woody biomass in order to educate the public of how they can best utilize this renewable energy source. Successful users and producers, "Champions of Biomass", were interviewed and educational videos were drafted in order to see the strengths and weaknesses of the industry. The opinions of the industry professionals lead to conclusion that woody biomass is a viable fuel option with the right conditions and infrastructure. This is a hopeful outcome. With increasing public demand and financial assistance the woody biomass energy sector may continue to be on the rise.

Poster #	S8
Name	Hennessey, Shannon, M
Affiliation	Rutgers University
Title	Genetic Approaches To Increase Anthracnose Resistance In Switchgrass

Abstract	Switchgrass (Panicum virgatum L.) is a warm season perennial prairie grass that is native to North America and is currently being grown and used for combustible fuels as well as liquid fuels (Parrish et al., 2008). As switchgrass acreage and commercial production increases, insect pests and diseases will become more prevalent. One disease that has already been identified is anthracnose caused by Colletochtricum navitas (Crouch et al., 2009). Very little is known about anthracnose disease on switchgrass, however, differences in susceptibility have been observed among cultivars of switchgrass. Breeding for anthracnose resistance may reduce the risk of yield losses as well as reduce the economic costs of fungicide treatments. In order to accomplish the successful breeding of anthracnose resistant switchgrass the current cultivars, breeding lines, and germplasm must be rated and evaluated. The objectives of this project are to identify resistant and susceptible genotypes through visual rating of switchgrass germplasm in newly established and mature breeding nurseries located in New Jersey and Pennsylvania, and to isolate C. navitas from infected leaf tissue of diverse switchgrass genotypes in multiple locations. These isolates will be used for further research on the population genetics of the pathogen.

Poster #	S9
Name	Jiang, Wei
Affiliation	Penn State
Title	A Multi-Component Analysis Framework for Assessing Marginal Lands for Growing Bioenergy Crops
Abstract	Biomass has been a resource for energy and materials in the northeastern U.S. for hundreds of years, and has the potential to dramatically increase its role in the decades to come. The region has high agricultural productivity, well-developed transportation and fuel distribution infrastructure, technologically adept human and financial resources, and substantial demand for advanced biofuels, biopower, and bioproducts. A major critique of large scale biomass production is competition for land between food and energy crops. A commonly suggested solution is to limit energy crops production to marginal lands. Biophysical marginality is often used when discussing marginal lands. However, as important is the socioeconomic marginality. One of the benefits of bioenergy crops is that they grow well on marginal lands. By combining socioeconomically margin with biophysical margin, we can provide a comprehensive map of marginal lands for food crops, and in so doing identify lands targeted for energy crops. This poster focuses on assessing marginal lands.

Poster #	S10
Name	Krishnan, Kavya
Affiliation	State University New York - College of Environmental Science and Forestry (SUNY ESF)
Title	Development of tools for rapid phenotyping of photosynthetic traits in shrub willow (Salix spp.) bioenergy crops
Abstract	Shrub willow(Salix spp and hybrids) have emerged as an important bioenergy and biofuel crop. Shrub willow biomass can be converted to heat and electricity or ethanol biofuel. The ability of shrub willow to grow on marginal soils with low inputs of fertilizer or pesticides makes it a particularly advantageous bioenergy crop. The objective of the project was to develop tools that can rapidly measure traits related to photosynthetic activity and N uptake among different genotypes of shrub willow. A Minolta SPAD 502 meter was used to estimate leaf nitrogen levels by measuring chlorophyll fluorescence, a relationship that has been affirmed in previous research with shrub willow. Total nitrogen levels were determined for batches of leaves that produced a range of SPAD readings, revealing a weak correlation between total N and SPAD values. SPAD readings were used to estimate N accumulation in a greenhouse trial involving a range of five nitrogen fertilizer treatments and six cultivars. SPAD readings were also collected in field trials to compare N levels in fertilized and non-fertilized stands and in a trial with clover cover crop or suppressed clover cover crop.

Poster #	S11
Name	Liu, Weiguo
Affiliation	West Virginia University
Title	Life Cycle Assessment of Biomass Harvest and Logistics in Northeastern U.S.
Abstract	A cradle-to-gate life cycle assessment (LCA) was conducted to assess the environmental and economic impacts of biomass harvest and logistics in terms of land usage, energy and water consumption, GHG emissions, and associated costs of each phase in the northeastern biomass supply chain. The LCA process consists of the following main components: land preparation, field management, harvest, storage, transportation and preprocessing and biorefinery. The function unit was 1000 MJ. An optimization process of the production, cost effectiveness and logistical strategies was also considered in the analysis. Sensitivity analyses of the environmental benefit to total investment were examined by feedstocks availability, carbon credit, capital cost, liquid fuels yield and demand. The GHG emission results were converted to CO2 equivalent amount based on the global warming potential indicated by IPCC. Future work will focus on biorefinery operation strategies and logistic scenario optimization.

Poster #	S12
Name	Martino, David, G
Affiliation	West Virginia University
Title	Biomass Preprocessing and Pretreatment for Biofuels and Bioproducts
Abstract	Biofuels from lignocellulosic materials is a major avenue of renewable energy being pursued in both the public and private sectors. Many pretreatments are being researched, including the use of ammonia in either an aqueous or gaseous state. However, ammonia is highly toxic and dangerous to handle, thus increasing the cost of the pretreatment process. Urea is a non-toxic alternative as an additive to the pretreatment process and can dissolve in solution to form ammonia. This research is to determine if urea added to a hot water extraction is a suitable pretreatment for hybrid poplar and miscanthus for the removal of sugars. Without any other refining processes, 17% of the total glucose was extracted from hybrid poplar, while 71% of the total glucose was extracted from miscanthus. This project also determines the energy content of the extracted material, when formed into pellets with varying blends. When comparing the blended to the pure pellets, the energy content did not significantly change, but the average compression strength of the blended pellets increased.

Poster #	S13
Name	McCarthy, Brittany, B
Affiliation	Delaware State University
Title	Identification, cloning, and expression of a full-length methyltransferase gene from switchgrass (Panicum virgatum L.) genotypes AP13 and VS16

Abstract	Enzymes known as methyltransferases methylate cytosine bases on DNA, therefore affecting gene expression. Methylation, a type of epigenetic modification, has been studied in plants such as Arabidopsis, but the methylation in potential biofuel crops such as switchgrass (Panicum virgatum L.) has not been analyzed extensively. There are four major classes of cytosine-5 DNA methyltransferases that have been studied in plants: the METI family, the CMT family, the DRM family, and the Dnmt2 family. Our research involves METI, a maintenance methyltransferase that encodes for a protein similar to Dnmt1, a mouse methyltransferase. Our goal is to identify, clone, and express a full-length methyltransferase gene from switchgrass genotypes AP13 and VS16. AP13 is derived from the lowland cultivar, Alamo, and VS16 is derived from the upland cultivar, Summer. We will identify methyltransferase sequences and design primers using bioinformatics tools, perform polymerase chain reaction (PCR), and gel electrophoresis. The DNA will be cut with restriction enzymes so it can then be ligated into an expression vector and grown in competent cells to select for expression and protein production. ChIP-Seq, a process in which a protein will be introduced to a host organism to generate antibodies, will be utilized to pull the desired protein out of the switchgrass. Because this class of methyltransferases is used for maintenance methylation as identified in other organisms, characterizing this methyltransferase may lead to a better understanding of methylation inheritance in switchgrass. Learning more about the epigenetics of switchgrass will be very beneficial to study bioenergy field traits and could eventually lead to a more efficient biofuel crop.

Poster #	S14
Name	McDonough, Tyler
Affiliation	The Pennsylvania State University
Title	Effects of Torrefaction Processing on Lignocellulosic Biomass
Abstract	The purpose of this research is to examine the effects of torrefaction processing in regards to northeast woody and warm-season biomass. Torrefaction is a thermochemical treatment that significantly alters the compositional properties of biomass, creating a more efficient product for bioenergy feedstock application. Three separate biomass products underwent torrefaction treatment and were further analyzed for the purpose of these experiments; miscanthus, switchgrass, and red oak wood. The primary variables taken into consideration consisted of time duration and applied temperature. Each biomass product was subject to a 30, 60, and 90 minute treatment period at 200, 220, and 240 degrees Celsius resulting in nine total samples. The chemical alterations as a result of the torrefaction process have proven to increase biomass hydrophobicity, grindability, and energy density. Moisture content of each sample was calculated pre- and post-torrefaction, with the raw biomass moisture content ranging from 7-10%, as opposed to 4-7% for the torrefied product. Results also indicate that the increase in both time and temperature are positively correlated to mass loss.

Poster #	S15
Name	Nobert, Heather
Affiliation	West Virginia University
Title	Impact of biochar application on willow growth in West Virginia over a diverse landscape

Abstract	Encouraging the development of perennial energy crops, including willow, on abandoned mine lands and marginal agricultural lands is a key overall objective of the Northeast Woody/Warm-season Biomass Consortium (NEWBio). Little work has been initiated in West Virginia on the development of shrub willow bioenergy crops on marginal lands for sustainable dedicated feedstock production. The goal of this project is to establish a series of replicated willow plots to investigate growth rates of willow on marginal lands as well as how biochar applications impact productivity. Four research sites were established in West Virginia for this effort and include: 1) reclaimed surface mine (30 years post-reclamation) 2) reclaimed surface mine (10 years post-reclamation) 3) marginal agricultural land, and 4) agricultural land (reference site). At each site, 6 plots were randomly located for a total of 24 plots. Three of the plots serve as reference plots and the remaining three will serve as treated plots. Equivalent applications of biochar were distributed on each treated plot (~14/T/acre). Soil health and microbial samples were collected and sent for processing. Mortality and growth samples were taken during June of 2013. The research plots will be monitored for a period of 2 years and the impacts of biochar additions and site qualities will be investigated.

Poster #	S16
Name	Ramcharan, Amanda, M
Affiliation	Pennsylvania State University
Title	A Model for the Decline in Percentage Nitrogen of Miscanthus x giganteus with Increasing Plant Mass
Abstract	Miscanthus x giganteus is a perennial biomass crop. The exact nitrogen (N) requirements of this crop are yet to be determined. Preliminary modeling results show that N dilution during biomass growth is the same as maize for yields less than 20 Mg/ha; beyond this, the dilution effect appears to vary. Results suggest that the N dilution effect for miscanthus diverges significantly from previous models of N dilution for C4 crops.

Poster #	S17
Name	Stow, Brenna, M
Affiliation	Penn State University (for the summer) I attend the University of Wisconsin - Madison.
Title	Growing Biomass on Marginal Soils
Abstract	The idea behind many biomass crops is to grow them on "marginal soils" or land not suitable for high-end agricultural use. Little is still known about challenges related to developing these varying types of land and the crops to be grown on them. This presentation summarizes some challenges observed with shrub willow, switchgrass, and miscanthus in their second year of growth on marginal soils. It also highlights some topics to address when moving forward.

Poster #	S18
Name	Vendetti, Vincent
Affiliation	Penn State
Title	Relating Subjective Quality to the Durability of Pellets

Abstract	The purpose of this research is to make a direct correlation between a subjective quality scale for rating pellets and a durability rating scale. The material that was tested consisted of two sizes of switchgrass grind that had been formed into pellets. The pellets that we tested had a number of moisture contents ranging from 13-30%. The pellet quality is based on a subjective analysis that is done by the pellet maker. Pellets are rated on a 0-10 scale for subjective quality. The durability scale is based on a test procedure that we created to perform on our numerous test samples. It is a measurement based on mass before and after the procedure is performed.

Poster #	S19
Name	Zuroff, Trevor
Affiliation	Penn State
Title	Development of a consortia-mediated bioprocess for producing ethanol from switchgrass
Abstract	In this work we demonstrate the use of a symbiotic microbial consortium which improves conversion of both cellulose and lignocellulose (Pancium virgatum) to ethanol. We sought to develop a process for consolidated bioprocessing (CBP) of lignocellulosic materials. CBP processes are typically limited by, among other factors, the lack of a suitable organism to complete the required hydrolysis and fermentation steps. As an alternative to single culture bioprocessing, mixed cultures or consortia represent a potential solution to achieve the appropriate combination of metabolic and hydrolytic properties. The stability of such consortia and lack of simplistic bioprocessing are often cited as inhibitors of this type of approach; these were key challenges overcome in this work. A symbiotic consortium of the cellulolytic mesophile, Clostridium phytofermentans, and a cellodextrin fermenting yeast Saccharomyces cerevisiae cdt-1, was developed. Cooperation was induced through diffusion of oxygen into culture medium which acts to inhibit the growth of the obligate anaerobe, C. phytofermentans. When provided a soluble carbon source from C. phytofermentans hydrolysis of cellulose, the yeast metabolizes oxygen relieving the inhibitory effect. The symbiotic consortium outperforms mono-cultures by producing about two times more ethanol from both purified cellulose and Panicum virgatum (switchgrass). We will discuss current advances in controlling, optimizing and understanding this consortium approach in the context of a new, consortia-mediated, paradigm for biofuels production.

Poster #	FAC1
Name	DiFazio,Stephen,P
Affiliation	West Virginia University
Title	Salix Genome Mapping Using Genotyping by Sequencing
Abstract	The Salix purpurea genome is currently being sequenced by the DOE Joint Genome Institute. The genome sequence assembly contains thousands of contiguous segments, as is typical of short sequence read genome assemblies for complex eukaryotes. We have undertaken high density mapping in an F2 pedigree of Salix purpurea using “Genotyping by Sequencing” to generate segregating markers. We have generated 8,272 markers for 476 progeny and used these to create a dense genetic map for the 19 Salix chromosomes. We used this map to assemble the genome sequence into chromosomal scaffolds, ultimately anchoring 277 Mb of the approximately 320 Mb genome. We aligned this assembly to the genome of the model tree Populus trichocarpa and found a high degree of sequence synteny and conservation of chromosome structure. However, we did discover a large chromosomal rearrangement and fusion that is apparently fixed different within the Populus and Salix lineages. The apparent conservation of chromosomal structure is remarkable given that a common ancestor of these lineages underwent a whole genome duplication, followed by dramatic chromosomal rearrangements and widespread deletion of duplicate genes. This was apparently a relatively rapid and/or highly conserved process. This map and sequence resource will be invaluable additions to the Salix genomics toolbox, facilitating biofuels feedstock improvement efforts and many other applications.

Poster #	FAC2
Name	Richards, Brian K.
Affiliation	Cornell University
Title	Carbon Sequestration and Gaseous Emissions in Perennial Grass Bioenergy Cropping Systems in the Northeastern US
Abstract	Our project seeks to help define the sustainability of perennial grass bioenergy production on marginal lands in the Northeast US by characterizing crop yields, sequestration of soil carbon (C), and emissions of nitrous oxide (N2O) and methane (CH4). In 2011 we established a perennial grass strip trial on a 10-ha (16 ac) site (denoted S1) where prior use over the past 50 years was limited to occasional mowing or haying due to wetness of the soils. Quadruplicate ~0.4 ha strip plot treatments are switchgrass (Panicum virgatum v. Shawnee), switchgrass +fertilizer N, reed canarygrass (Phalaris arundinaceae v. Bellevue)+N, and non-converted control (fallow grassland). Nitrogen loadings were 74 kg N/ha (applied April or May for reed canarygrass starting 2012, and in June for switchgrass starting 2013). In 2012 we began similar monitoring of a second smaller site (S2) with mature switchgrass (v. Shawnee) stands planted in 2008. Three subplots were located on upslope, sideslope and bottom slope positions to capture soil drainage gradients on each of three strip plots that had preexisting N treatments of 0, 56 and 112 kg N/ha. Frequent emission chamber campaigns (n=36 chambers) began just prior to the June 2013 N application. Proximity to and concurrence of field operations with the S1 field site suggests that responses to temperature and rainfall measured by the S1 flux tower can be used to help interpret S2 chamber trends as well. We are also conducting less intensive field trials on sites representing other soils and landscape conditions, including a trial being established by cooperator Beneterra Agritech in Sherrill NY, and a mature switchgrass stand at the State University of NY at Cobleskill.

Poster #	FAC4
Name	Spatari, Sabrina
Affiliation	Drexel University
Title	Life Cycle Assessment of Biomass Densification through Fast Pyrolysis
Abstract	Biomass resources are under development in the US Northeast region to support low carbon energy markets for heat and power in the near-term and drop-in biofuels, including aviation fuels in the mid-term. This project investigates the development of biomass resources from short-rotation forestry (willow), perennial grasses (switchgrass and miscanthus); and from farm-scale production of agricultural waste (mixed agricultural residues, grasses, and equine waste) and perennial grasses (switchgrass) for conversion to catalytic and non-catalytic pyrolysis products across the US Northeast and in focused supply counties in the region.

Poster #	FAC6
Name	Crawford, Ryan, V
Affiliation	Cornell University
Title	Geographic Diversity of Cornell University NEWBio Switchgrass Nurseries

Abstract

Switchgrass nurseries were established and in 2008 and 2009 with diverse accessions from the northeastern US and elsewhere. For 2012, selections were made on the basis of height, vigor, disease and pest resistance, uprightness, and seed germination. Selected plants were assigned to one of six NEWBio seed production nurseries. This poster depicts the geographic origin of Cornell University NEWBIO switchgrass germplasm partitioned by nursery. The Early Flowering nursery is the most geographically diverse, while there is substantial overlap between the Late Flowering and Cool Temperature Germination nurseries. There are also selections of high-performing genotypes from named cultivars Cave-in-Rock, Shelter, and Kanlow.