Biofuels done right: Integrating agricultural production with new technologies to create a sustainable biofuel economy

- **Food and fuel: The technical potential of increasing bioenergy production and decreasing greenhouse gas emissions in the United States using land efficient animal feeds**
  Dr. Bryan Bals, Biomass Conversion Research Laboratory, MSU
- **Land usage in a sustainable landscape, feedstock logistics and the operation of Regional Biomass Processing Depots**
  Pragnya Eranki, Biomass Conversion Research Laboratory, MSU
- **Potential for biofuel and animal feed production from low-input mixed-species feedstocks with comparison to conventional corn stover**
  Rebecca Garlock, Biomass Conversion Research Laboratory, MSU

SESSION ABSTRACT

There is a great deal of controversy surrounding biofuel production's sustainability, particularly related to agricultural land use. Many believe that it is not possible to adequately produce large quantities of biofuels while simultaneously ensuring sustainable food production and environmental benefits. Despite these concerns, we believe we can create a large-scale sustainable biofuel future through proper development of key technologies both on the farm and in biomass processing. This session demonstrates some of the results achieved in the Biomass Conversion Research Laboratory, from the farm scale to the national technical potential of biofuels.

PRESENTATION ABSTRACTS

Food and fuel: The technical potential of increasing bioenergy production and decreasing greenhouse gas emissions in the United States using land efficient animal feeds

This paper presents a new approach to agriculture land use with biofuel production, in which current US cropland is intensively managed to either produce both food and fuel on the same acreage or to increase food production, allowing additional land to be freed exclusively for biofuel production. Double crops can be grown on the same land as corn or soybeans, increasing the amount of stover removed and providing a fiber source for ruminants. In addition, protein recovery from early harvest hays can displace soybean production, while pretreating switchgrass or corn stover with ammonia pretreatments can displace traditional forages in cattle diets. Likewise, biofuel production can be performed on idle or Conservation Reserve Program land.

In this study, the theoretical maximum amount of biofuel produced on current cropland without affecting overall food production is considered. Current fiber, energy, and protein needs for human consumption, animal feed, and exports are met. This study suggests that approximately 50% of current US gasoline consumption can be displaced by biofuels grown on current cropland in the United States. This result is consistent across multiple sensitivity scenarios, with the largest changes being due to changing crop yields and the loss of corn land or cover crops. Net soil organic carbon increases in this scenario; however, nitrate leaching is greater than if little to no biofuels are produced. United States greenhouse gas emissions decrease by 670 Tg CO_2-equivalent per year in this scenario, due primarily to decreased fossil fuel emissions. This is equivalent to nearly 10% of total GHG emissions.

Land usage in a sustainable landscape, feedstock logistics and the operation of Regional Biomass Processing Depots (RBPDs)

In order to produce large quantities of lignocellulosic ethanol as the primary product, biorefineries handling enormous tonnages of a large variety of feedstocks are required; This implies contracting with numerous individual farmers, interrupted feedstock supplies, large transport and storage costs of feedstock and other business and market power issues. These set-backs can be addressed by proposing a network of facilities called "Regional Biomass Processing Depots" (RBPDs) which would potentially be able to bridge the gap between feedstock suppliers and biorefineries for the production of lignocellulosic ethanol, animal feed and other by-products like electricity. In its most elemental form, an RBPD would procure feedstock, pre-process/pre-treat it, deliver it in an arrangement that satisfies the biorefinery requirements and return by-products to the appropriate end-user, taking into consideration that all these steps are carried out in an economically viable, relatively the most environmentally advantageous and a socially profitable approach.

The aim of this study is to allocate areas in a landscape to various feedstocks based on their sustainability and ethanol/animal feed-yield characteristics, to delineate the operation of an RBPD, to estimate the total energy consumption and emissions generated due to the operation of the system that consists of feedstock suppliers, the RBPD and all related transportation and to assess the sustainability of this distributed processing system by comparing it with values from a centralized biorefinery.

Potential for biofuel and animal feed production from low-input mixed-species feedstocks with comparison to conventional corn stover

Feedstock cost is predicted to be the largest contributor to overall cost for the biorefinery, and this percentage will only increase as the industry matures. Because of this, finding diverse sources of inexpensive, highly digestible materials is very important for the success of the industry. Compared to conventional agriculture, low-input mixed-species feedstocks, such as biomass from native prairie grasslands, require minimal agronomic inputs and maintenance, thus decreasing on-farm greenhouse gas emissions and nitrogen runoff. In addition, mixed species feedstocks can provide more valuable ecosystem services. However, these fields may not produce the high yields necessary to be economically competitive. To this point, most research on energy generation from mixed-species feedstocks has focused on thermochemical conversion methods and, although various groups have predicted the ethanol yield from biochemical conversion, there has been no experimental research to analyze this method. One benefit of the biochemical conversion route is the potential to alternatively use pretreated biomass produced from these fields as a higher value animal feed.

In order to investigate the feasibility of using low-input mixed-species feedstocks for biofuel and animal feed production, we tested five replicates (fields) of differing species composition from the old field treatment at the Kellogg Biological Station at Michigan State University. Ammonia fiber expansion (AFEX) pretreatment followed by either enzymatic hydrolysis or in vitro rumen digestibility were performed on these samples in order to determine their value as both a biofuel feedstock and an animal feed compared to untreated material. An economic analysis from the perspective of the biorefinery was also conducted and the results were compared to corn stover and a late-successional old field sample. The results indicate that the biorefinery economics depend heavily on the overall sugar content and the digestibility of the feedstock, which in turn is dependent on the species composition.

PRESENTER BIOSKETCHES

Dr. Bryan Bals, Biomass Conversion Research Laboratory

I am a postdoctoral researcher; I obtained my doctoral degree in Chemical Engineering in November 2009. My bachelor's degree was from Rose-Hulman Institute of Technology, in chemical engineering with a focus on biochemical engineering. My interest in bioenergy stems from the urgent need our nation has to reduce its dependence on oil for political, economic, and environmental reasons. I believe we as a nation should move towards reducing our oil consumption immediately, and ethanol as a replacement for gasoline is the best near-term solution. I firmly believe that the work in making cellulosic ethanol feasibile will make a significant, positive impact in the world, and would like to help bring about this change as much as possible. My research is focused on determining the feasibility of co-producing a protein concentrate for use as animal feed from switchgrass. This could significantly reduce the cost of ethanol production as well as increase the amount of land available for energy crops. My emphasis is on applying data obtained in the laboratory to a "real world" scenario, and so looking at the overall process rather than simply the proteins recovered is vitally important to my work.

Pragnya Eranki, Biomass Conversion Research Laboratory

Pragnya Eranki obtained an undergraduate degree in Chemical Engineering from Jawaharlal Nehru Technological University, India. She is currently a 3rd year PhD student in the Department of Chemical Engineering at Michigan State University and a member of the Biomass Conversion Research Lab (BCRL) and the Great Lakes Bioenergy Research Center (GLBRC).Her research interests include Life Cycle Assessment, design of sustainable landscapes for biofuel feedstocks and modeling of biofuel production systems.

Rebecca Garlock, Biomass Conversion Research Laboratory

I'm a native Michigander, a third-generation Spartan, and have plants and teaching in my genes. You could honestly say my blood runs green. My parents are foresters and I think my mom is more excited about my research than I am, if that's possible. My goal is to learn how to use my love of plants to help wean the world off of fossil fuels in favor of more environmentally friendly, renewable alternatives. I'm especially interested in developing fuel crops for cold-weather climes.