Checking in with CenUSA

Sustainable Production and Distribution of Bioenergy for the Central US

CenUSA Bioenergy is a multidisciplinary project funded by the U.S. Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA Initiative Competitive Grant No. 2011-68005-30411). CenUSA's goal is to research the production and use of perennial grasses on marginal lands for use as alternative biofuels and bioproducts. More information is available at www.cenusa.iastate.edu.

Stuart Birrell[1], Professor of Agricultural and Biosystems Engineering at Iowa State University, spoke with CenUSA Communications Intern Tyler Worsham in February 2019 about his work and experience as a CenUSA co-project director in the area of feedstock harvesting and logistics A primary topic that was emphasized in the discussion was the need for the feedstock supply chain to be made as efficient as possible in order to improve biomass density and the timeliness of operations.

How did you initially get involved with CenUSA?

"I had been doing some work in the harvesting of corn stover products. When the CenUSA project started, I was asked to join them and look at the harvest machinery and harvest logistics."

What made you an ideal candidate for your co-project leadership position?

"I think it was because of my background, my knowledge of agricultural machinery and operations, and the previous work I had done involving the development of stover harvesting systems."

In what ways did the project challenge and broaden your knowledge and skill set? "I think it was broadened by working in a multidisciplinary group and seeing how there are interactions between all of the different phases in the complete development of a new industry. Some of the challenges exist for many of the same reasons. Everyone brings a different perspective to the problem, and you have to discuss those different perspectives to see how you can make the system as efficient as possible."

Have you worked in any other projects as large or as well funded as CenUSA?

"No. I have worked in some large projects, but none of them were at the funding level of CenUSA as a complete project. For my individual component, yes, I've worked in projects that were funded just as well, if not better, but not as an integrated project."

Could you briefly describe some of those other projects?

"A significant portion of my research has been in the development of machinery systems, and many of these have been industry supported."

[1] Learn more about Stuart Birrell at https://www.abe.iastate.edu/stuart-birrell

In what ways were they different from CenUSA?

"In general, the scope of this research tends to be more targeted than the scope of CenUSA because industry-sponsored research tends to focus on one particular aspect or need. It doesn't have competing criteria and constraints that are common in multidisciplinary integrated projects."

What new ideas and disciplines were you exposed to as a part of your experience with CenUSA?

"CenUSA provided exposure to seed breeding and conversion technologies, as well as the potential for interaction between these technologies and machinery systems. Optimal harvesting operations are influenced by seed genetics and agronomic practices, and in turn, harvest operations, timing and performance can significantly affect the conversion technologies. The optimal biomass supply chain can be significantly affected by the relative interaction between the genetics, agronomic practices, machinery systems and conversion technologies. A decrease in cost in one area might be a small decrease, but it can significantly influence cost in another area. Quality is also a factor. A small change in quality in one area can also have a significant effect on the costs in another area."

Read our White Paper

Did you and your team encounter any unforeseen obstacles coming into the project that you didn't expect?

"I wouldn't say 'unforeseen.' It is always a challenge when you have a very large project with a number of different disciplines. It's always a challenge to keep all of the disciplines working together on top of having enough focus to get real results in your own specific area."

What were some noteworthy discoveries and successes that you achieved?

"We saw a lot of success in looking at the sustainability of the harvest system and managing and minimizing the variations in the quality of the agricultural residue to improve the processing efficiency."

How might future advancements in harvesting methods and machinery help farmers in the future?

"Particularly in the biomass industry, it really comes down to improving the logistics and the timeliness of operations. That is probably the biggest hurdle to the adoption of the technology. Timeliness affects the operation of their primary income. In many ways, reducing the number of operations that have to be done through the feedstock chain have significant effects on costs and on the timeliness of operations."

In what ways can harvesting and transportation can be improved in the future?

"It really boils down to improving density, reducing the number of operations required and minimizing both the biological and physical material loss during storage. We need to increase the bulk density and value density of the material as close to the field and production unit as possible. The density increase should occur as close to the production field a possible with distributed biomass pre-processing units so that the pre-processed biomass can then be a transported and sold as a commodity feedstock for the biochemical industry to convert into a range of chemical and energy products."

CenUSA White Paper

Could you explain how your work on the harvesting and logistics objective differs from that of Kevin Shinners (the other co-project director in harvesting and logistics)?

"Kevin has a lot of expertise in storage. Outside of that was harvesting, so a lot of what we were doing was looking at ways of maintaining quality during harvesting and moving the increase of density as early as possible. We also looked at sustainability. From that point of view, we have to maintain the organic matter of the soil. If you are harvesting biomass material, you are taking more carbon off the field. Conventional agricultural crop production practices, however, tend to include significant tillage to incorporate agricultural residues which tend to reduce accumulated soil organic matter (soil carbon). As you till the soil, you release a lot of the natural carbon that was stored in the soil. I think there is a significant benefit in harvesting some of the material on the surface while reducing tillage intensity so you can maintain the carbon already stored in the soil. I think the economic benefits and the potential for better sustainable systems of production are significant."

Is resolving the issues of density and so on a matter of throwing more research at the problem, or are there other factors involved?

"There is a need for an increase in research to optimize the feedstock supply chain. At present, most biomass feedstock chains are based on single individual units of biomass, generally large square or round bales. These unit operations significantly increase harvest, transportation and handling costs compared to supply chains based on bulk handling of the material. We only have to look at grain production to see the advantages of bulk supply chains, comparing when grain was harvested and transported in bags to the modern practices where grain is harvested, stored and transported in bulk by trucks, railcars, barges and ships. Research is needed to develop bulk commodity-based systems for biomass supply chains."

Stuart Birrell CenUSA Bioenergy Work Product

- ✓ Fact Sheet: Logistical Challenges to Switchgrass (Panicum virgatum L.) as a Bioenergy Crop. Amy Kohmetscher, Ohio State Univ. & Stuart Birrell, Iowa State Univ. (2013). http://articles.extension.org/pages/68053/logistical-challenges-to-switchgrass-panicum-virgatum-l-as-a-bioenergy-crop

- ✓ Webinar: Switchgrass and Bioenergy Crop Logistics. 2012. (36:44). http://youtu.be/OGEd4KZOE2Q

Publications

- ✓ De Souza, A., **S.J. Birrell**, B.L. Steward & S. Ksketri. 2015. Moisture Content and Bulk Density Prediction Using Dielectric Properties for Switchgrass and Corn Stover. ASABE Paper No. 2160026, Am. Soc. of Agric. Engineers, St. Joseph, MI. http://elibrary.asabe.org/azdez.asp?search=1&JID=5&AID=45752&CID=norl2015&v=&i=&T=1&urlRedirect=.%22%20%5Ct%20%22_blank. (Open Access)

- ✓ Emerson, R., A. Hoover, A. Ray, J. Lacey, M. Cortez, C. Payne, D.L. Karlen, **S.J. Birrell**, D. Laird, R. Kallenbach, J. Egenolf, M. Sousek & T. Voigt. 2014. Drought effects on composition and yield for corn stover, mixed grasses, and Miscanthus as bioenergy feedstocks. Biofuels 53:(3) 275-279. doi: 10.1080/17597269.2014.913904

- ✓ Karkee, J. & **S. Birrell**. 2015. Least cost machinery analysis for two different biomass collection methods. ASABE Paper No. 2190753. Am. Soc. of Agric. Engineers, St. Joseph, MO.

- ✓ Karlen, D.L., J.L. Kovar, **S.J. Birrell**. 2015. Corn Stover Nutrient Removal Estimates for Central Iowa, U.S.A. Sustainability 7(7): 8621-8634. doi: 10.1007/s12155-012-9198-y. (Open access)

- ✓ Khanchi, A. & **S.J. Birrell**, 2017. Drying models to estimate moisture change in switchgrass and corn stover based on weather conditions and swath density. Agric. For. Meteorol. 237-238: 1-8

- ✓ Khanchi, A. & **S.J. Birrell**, 2017. Effect of rainfall and swath density on dry matter and composition change during drying of switchgrass and corn stover. Biosystems Engineering 153:42-51

- ✓ Khanchi, A. & **S.J. Birrell**. 2015. Influence of weather and swath density on drying characteristics of corn stover. ASABE Paper No. 2190753. 2015 ASABE Annual International Meeting Am. Soc. of Agric. Engineers, St. Joseph, MI. doi: 10.13031/aim.20152190753). St. Joseph, Mich.: ASABE. http://elibrary.asabe.org/azdez.asp?search=1&JID=5&AID=46290&CID=norl2015&v=&i=&T=1&urlRedirect=

- ✓ Khanchi, A., **S. Birrell** & R.B. Mitchell. 2018. Modeling the influence of crop density and weather conditions on field drying characteristics of switchgrass and maize stover using random forest. Biosystems Eng. 169: 71-84. https://doi.org/10.1016/j.biosystemseng.2018.02.002

- ✓ Khanchi, A., B. Sharma, A.K. Sharma, A. Kumar, J.S. Tumuluru & **S.J. Birrell**. 2018. Effects of biomass preprocessing technologies on gasification performance and economic value of syngas. Book

chapter published in Tumuluru, J.S. ”Biomass Preprocessing For Biofuels Production: Mechanical, Chemical And Thermal Methods.

- ✓ Moore, K.J., **S. Birrell**, R.C. Brown, M.D. Casler, J.E. Euken, H.M. Hanna, D.J. Hayes, J.D. Hill, K.L. Jacobs, C.L. Kling, D. Laird, R.B. Mitchell, P.T. Murphy, D.R. Raman, C.V. Schwab, K.J. Shinners, K.P. Vogel, J.J. Volenec. 2014. Midwest Vision for Sustainable Fuel Production. Biofuels 5(6): 687-702. doi: 10.1080/17597269.2015.1015312

- ✓ Sharma, B., **S.J. Birrell** & F.E. Miguez. 2015. An integrated GIS and mathematical model for optimal siting of bioethanol plants in the U.S. ASABE Paper No. 218705, Am. Soc. of Agric. Engineers, St. Joseph, MO.

- ✓ Sharma, B., **S. Birrell** & F.E. Miguez. 2017. Spatial modeling framework for bioethanol plant siting and biofuel production potential in the U.S. Applied Energy 191: 75–86

- ✓ Sharma, B., E. Brandes, A. Khanchi, **S. Birrell**, E. Heaton & F. E. Miguez. 2015. Evaluation of Microalgae Biofuel Production Potential and Cultivation Sites Using Geographic Information Systems: A Review. BioEnergy Res. 8(4): 1714–1734. doi: 10.1007/s12155-015-9623-0

- ✓ Sharma, B., E. Brandes, A. Khanchi, S. Birrell, E. Heaton & F. E. Miguez. 2015. Evaluation of Microalgae Biofuel Production Potential and Cultivation Sites Using Geographic Information Systems: A Review. BioEnergy Res. 8(4): 1714–1734. doi: 10.1007/s12155-015-9623-0