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). The goal of the project is to research the production and use of perennial grasses on marginal lands for use as alternative biofuels and bioproducts. Learn more about CenUSA at www.cenusa.iastate.edu.

Jeffery Volenec[1], a CenUSA Bioenergy co-project director in sustainable feedstock production systems and a professor of agronomy at Purdue University, spoke with CenUSA Communications Intern Tyler Worsham in December 2018 about the nature of his role and how his work with CenUSA centered on determining best practices for cost-effective feedstock production.[2]

Jeff Volenec

How did you get involved with CenUSA?

"Well, like most of these large USDA-NIFA (National Institute of Food and Agriculture) grant projects, everyone was talking about how to best create a project that met the needs of the program. There were a number of us talking about what our strengths were and how to meet the goals of the RFA (request for application).

In actuality, there were a couple of groups. Ken Vogel in Nebraska was conversing with us, and others at Nebraska were conversing with people at Iowa and Minnesota. In the end, rather than having two competing proposals from the central U.S., it was decided to coalesce the various strengths across these institutions, and as you know, Purdue in Indiana was pulled in as one of the partners."

What made you an ideal candidate for your leadership position in feedstock development?

"We did a couple of things. First of all, we sort of knew that bioenergy was becoming a point of interest for the federal government again with climate change and other things happening, so we had already put a large number of plots in place that were ready to go. Otherwise, it's a two-year proposition before we can even start researching switchgrass. We were already planning plots and already had perennial grasses established. We also did a fair amount of work on switchgrass research in the late 80s.

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[1] Learn more about Jeff Volenec at https://ag.purdue.edu/agry/directory/Pages/jvolenec.aspx

[2] All of the words and ideas expressed in this interview fairly and accurately represent the speaker. Some quotes may be paraphrased for brevity and clarity. The opinions expressed in herein do not necessarily reflect those of Iowa State University, USDA-NIFA, Purdue University, Ohio State University, USDA-ARS, the University of Minnesota, the University of Nebraska, Lincoln, the University of Vermont, or the University of Wisconsin.

The third thing is we have a team and some facilities that are unique; facilities that allowed us to really look at the environmental impacts of growing perennial grasses. This includes the ability to measure greenhouse gas production, off-site water contamination, nitrate losses to water and our ability to directly compare the agronomic and environmental performance of biomass systems to conventional agriculture, including corn and soybean production.

I really wasn't the lead. I was one of several co-leads in feedstock production along with Rob Mitchell (ARS-NE) and David Laird (Iowa State University). We had a good group."

What in your previous work history best prepared you for your work at CenUSA?

"I think the work we did in the 1980s for the Department of Energy was crucial. We compared switchgrass as the native prairie system to cool season systems like reed canary grass, tall fescue, sorghum and other annual systems, so we had a fair amount of experience, but then my academic training was also in perennial grass growth, development, their responses to nitrogen and other related topics. That was my formal training at the University of Missouri, but then we also did a fair amount of work here on that topic directly."

CenUSA Bioenergy White Paper

In what ways did the project challenge and broaden your professional knowledge and skill set?

"The fun part was the large number of disciplines involved, going all the way from breeding and genetics to bioprocessing and economics. I am familiar with the breeding aspects, and I enjoy it because almost all of our work involves contrasting genotypes, varieties or lines, as well as how they respond to environmental or agronomic management.

Then we also got to talk with people in engineering like Robert Brown at Iowa State and with those in the conversion process about their challenges. We talked with the people involved with safety issues, economic issues, social science issues, farmer acceptance and what it's going to take to actually grow these things. There were a lot of aspects along the complete supply chain that were important."

You mentioned all of these different fields. Was there anything with which you had little experience going into the project?

"it's probably the conversion part. I pay attention to the forage conversion in the context of livestock. That's critical. I've worked with alfalfa and other forages for 35 years. Forage quality is important, so I was keenly aware of the role of fiber quality, composition and lignin, as well as how they affect animal performance, milk production and stuff like that. I'm less familiar with the chemical conversion in an industrial sense, so that was interesting."

Have you worked with any other projects as large or well-funded as the current project?

"No, this one was about $25 million. The next one in terms of scale was a project with NASA which had $10 million. It was many years ago. The movie "The Martian" sort of mimicked this. It was about what it would take to put a colony on Mars and what it would take to supply food and water there. Our role in that project was using perennial plants to recycle water coming out of the waste streams."

So other than funding, what made CenUSA different from any of your other government-funded projects?

"Well, I think the breadth of activity across all of these disciplines made it different, as well as the number of people involved, especially (the number of people) in the area of Extension where they dedicated a third of the money to education and outreach activities. It's just that typically with most grants that are a half-million or a million dollars, you often don't have the option to invest this much money into undergraduate education, Extension and outreach. We do that after the research is done, and we translate it in order to produce fact sheets and other educational materials. This effort was directly embedded in the grant."

What was your specific role in feedstock development research? If you would, describe your day-to-day involvement in CenUSA?

"My day-to-day is sitting in an office answering emails and writing papers and grants. What we wanted to do was try to improve the efficiency of production. The cost of the feedstock is still a critical limitation. Getting it below $50-to-$60 per ton is critical to making this work, so you need to have very minimal nitrogen water inputs and things of that nature. We're doing this on marginal ground where you wouldn't normally grow your corn, soy or some other plant. It has to be done on inexpensive, cheap land, so our goal was to see how much biomass we can produce with minimal inputs and how that alters the composition. We were very interested in putting on less N (nitrogen), so there is less N in the tissues since it can alter the lignin composition in ways that make the feedstock utilization different.

That was our real concern, looking at radiation use efficiency, N-use efficiency and water use efficiency for an array of feedstocks. We didn't only look at perennial feedstocks. We also looked at corn stover and sorghums to have other comparisons. We also monitored soil health characteristics. If you're growing these things, you want to do it in a sustainable way, so we're really interested in knowing soil microbial populations to see if they changed.

We could only do so much plot work on research farms and places like that. We also had a significant modeling component where we looked at how much marginal land is there in the Midwest based on the production results in Indiana, Iowa, Nebraska and other places. We were involved in some SWAT modeling, that is the Soil Water Assessment Tool, which has a crop production module. We actually built a switchgrass module for that model, the excellent engineers we worked with at Purdue did this so we could estimate how many billions of tons of switchgrass we could produce marginal lands. That was a lot of fun as well.

I spend a lot of time in the office in my day-to-day. The most interesting work is done by the staff and the students who get to go to the field. We have a nimble group of six-to-eight people who go out and measure greenhouse gas emissions on the plot every Wednesday starting in March and going through November. I get to go out and give tours, take a look at plots and answer questions for the team if there are things that are out of the ordinary, but my day-to-day activities have unfortunately evolved into writing and trying to keep up with the data analysis. I make that available to the modelers, answer emails and teach."

Where do you see switchgrass and other perennial grasses 20 years from now?

"I think they're going to remain on the sidelines until the price of gas and petroleum changes. When the price of fuel goes up to $5 or $6 per gallon, which it inevitably will since petroleum is a limited resource, this research we have done and these plants we've created will have the dust brushed off of them, and we will have a start on what to do.

Right now, with cheap petroleum and current government policies favoring gas and petroleum, the (perennials) are going to remain as plants used for forage in the forage-livestock industry and wildlife. The real key is that someone is going to have to say it's worth building conversion plants because the price of the product will be worth something. Right now, it just can't compete with petroleum. It's an economic decision and a policy decision, not really an agronomic decision."

What are the most significant barriers to establishing a significant production of bioenergy?

"It's the economics and the policies. With cheap gas, it's just not going to happen any time soon. I don't even know if the conversion plants in Iowa are operating now with corn stover. I think they may have even shut them down. It's just not a good value proposition. I think they demonstrated that it can be done at scale. They've shown that it can work."

How do you think your research in particular will help make switchgrass a more viable alternative?

"I think what we've got is a basis for launching the industry when it's ready. I think we can provide the feedstocks, not only the switchgrass but also Miscanthus, the other perennial with which we worked a lot. The challenge is getting it established. If you can, with almost no nitrogen, produce 20 to 30 tons of dry matter, twice or three times what switchgrass can produce, if there is a place to sell it and it can be turned into fuel, that has some potential. Both switchgrass and miscanthus are viable candidates. I guess it's just a matter of the will of the people. If we as a country want to wean ourselves off petroleum, truly get into a bio-economy and work on climate change, this is a better way to do it."

"What we wanted to do was try to improve the efficiency of production. The cost of the feedstock is still a critical limitation. Getting it below $50-to-$60 per ton is critical to making this work, so you need to have very minimal nitrogen water inputs and things of that nature." *Jeff Volenec*

You mentioned that it's all policy more so than actually being capable of doing it. What do you think it would take to overcome that barrier? What do you think would have to happen for policy-makers to catch on to this?

“I think we'll need to sit back and look at the true cost of taking carbon reserves out of the ground and putting it into the air. No politician wants to talk about the cost of climate change. I've seen estimates in the last couple weeks with all of the wildfires, flooding and tornados. I've been around a long time, and I've never seen tornados in November and early December like the ones we've had in Illinois and Missouri. Things are happening that are costing a lot of money, and nobody wants to talk about it in the current political administration, but it's really the people, the voters who own this. If they don't want to vote people in who will serve their long-term needs, then it just isn't going to happen.

“When the price of fuel goes up to $5 or $6 per gallon, which it inevitably will since petroleum is a limited resource, this research we have done and these plants we've created will have the dust brushed off of them, and we will have a start on what to do.” *Jeff Volenec*

I also understand how politics work. I'm not naive to that. For politicians, the goal is to get re-elected, not to talk about things that make people uncomfortable, that might cost money to do or that might change the job structure. Take coal for example. It’s almost funny how some of the politicians in Washington talk about saving the West Virginia coal industry. Well, I'm very sensitive to local economies and the fact that people will be put out of work if the industry continues to wind down, but in the end, the total employment in coal is very small. It’s all been mechanized. This is a big conversation point, and locally it’s really important, but let's figure out how to get Amazon to put new facilities in West Virginia, for example. That's something I'd like to see. They put it in New York or Long Island, well, let's put it in West Virginia. Let's give those thousands of people a huge boost.

There are some things that can be done that the politicians don't want to do, and the voters don't seem to care too much, so when the environment continues to deteriorate, that will make people move and vote in the people who care. Maybe even the current people will realize we've dropped the ball. They're not evil folks, they're just reacting to what the voters want.”

Could you describe how the facilities at Purdue helped you with your research?

“We've got some really unique facilities for measuring the environmental performance of cropping systems. The water quality field station is the key facility where there are huge lysimeters. Think of a concrete box with no bottom in it. It's actually made out of a special kind of clay…There are 48 of those lysimeters. Some are about half the size of a football field...but most lysimeters are probably about the size of your kitchen table, maybe your bathroom floor. These are large, and they're expensive to build and run, but they allow us to get a really good idea of how much nitrogen goes on the corn, how much goes in the air, how much goes in the water and what's left in the soil. So with a system like this, we can really get a handle on mass balance and where things are going. Be it a herbicide, a fertilizer or if we put on manure and look at antibiotic movement...things like that, this (the facility) was really good for these things.”

What made Purdue the most ideal place for that research as opposed to some other facilities at other universities?

"This facility was built in the 90s. We would have built it in Iowa, Nebraska or some other place, but the estimated cost would be between $5 to $10 million dollars. A good chunk of the money would have gone to just building the facility and not even to doing the work. We shouldn't duplicate these things. We have to leverage what we've got, as we should.

Robert Brown and others brought the biochemical conversion strengths of Iowa State to bear, so we didn't have our people, our engineers participate in that. I think every institution has its own strengths. That we leveraged those strengths is what made this a special project. Even though they're location hundreds of miles apart, they worked out pretty well."

What were your personal contributions to the development of Liberty and other switchgrass varieties?

"We did some testing on 'Liberty' just as it was released, so we didn't have direct involvement in selection, but we did some final testing in small plots. A colleague of mine at Purdue, Keith Johnson, tested 'Liberty' against 'Shawnee' and some other genetic lines along with a whole array of other germplasms from Ken Vogel. We had 'Liberty' in small plots, testing it against Indiangrass, big bluestem and Miscanthus at several locations in the state. We did some final testing of it to get some potential information for the group."

Let's refine that question. What was your role in that testing?

"We grew it, fertilized it using best management practices, harvested it and then provided that data from all of these locations back to Ken (Vogel) and others so that they knew what the yields were relative to existing switchgrasses growing on adjacent plots. In the end, it was about a 15 percent bump over Shawnee and other switchgrasses that we normally grow."

What were some of your noteworthy successes, discoveries or opportunities you have achieved through this research?

"I think one thing that is very interesting is that we can grow considerable amounts of these

perennial grasses with minimal inputs of nutrients. One field site we had was incredibly depleted of phosphorus and potassium. A large part of one farm was very low on PNK (polynucleotide kinase). We had been cropping alfalfa and corn there. The PNK concentrations were so low the yields of alfalfa and corn would be reduced by at least 50 percent.

Even with very high N rates, the corn was really low yielding because of the PNK rates. Switchgrass and Miscanthus, but especially switchgrass, was incredibly productive under these really low PNK conditions. People often think of aspect, drainage, slope or shallowness of the soil. In this case, these soils were very marginal for soil fertility, and the plants did great. That's important because high potassium in the tissue kills the catalyst used in pyrolysis, so what they want is really low K (potassium) concentrations. It appears we can grow switchgrass quite readily with extremely low tissue potassium levels.

That was interesting, as well as getting good estimates of the input use efficiencies of radiation, water and nutrients like nitrogen. Those things were all very helpful. I think the modeling was a success. We were able to have a really good understanding of the breadth of where we might grow switchgrass and be able to produce tens or hundreds of millions of tons of material should the bioeconomy ever gain traction."

What were some unforeseen obstacles that you didn't expect to encounter?

"I don't know if there were many. Things ran pretty well. I think one would always say that we could've done even more if we had more resources. Having more money would have allowed us to hire another student or two to do more work and expand what we are doing, but if you were to ask anyone, they would probably say the same thing.

There's probably one big obstacle that remains an obstacle. What I'd like to see, if it is still doable, is the unifying of all of the data that was generated by the $25 million project into one database that is available for public use analysis and broader use because there is a lot of data collected at a lot of locations. One thing that didn't survive the budget cut when the project was originally going to be funded at $50 million before it was cut back to $25 million was the data curation and management piece. I'm a little sad that we were not able to bring all of our data together, and while it might not sound like a really hard thing to do, it's a monumental task. I could probably spend up to six months or a year personally doing it for the whole group, , but we can't afford to do it."

In what directions do you want to take your CenUSA research?

since everything is grant funded. One thing we are doing right now is that we're going back and using some of the same CenUSA plots on the water poly-fueled station in which the switchgrass and miscanthus remained. What we are doing now is coming in with other systems, particularly cover crops, to look at growing biomass after corn crop or with the corn crop.

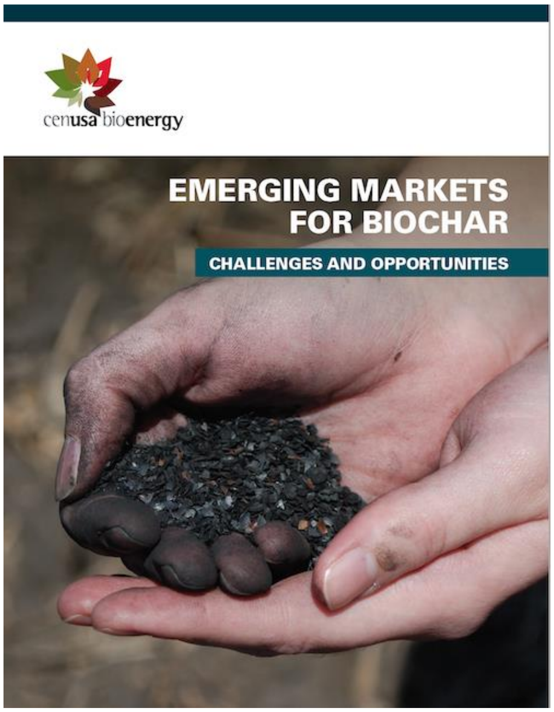
So we are looking at how to capture radiation water and nutrients within cropping systems that farmers might already have in place. What we are doing is comparing the productivity of those systems back to those that we had in the CenUSA program. It's looking at how a farmer might actually grow biomass around their corn-soy production and make money. That's one of the things we are currently doing. We'll keep looking at opportunities to leverage the perennial grass systems and use them as controls in other biomass-related research."

How will the work done in CenUSA impact the goal of 10 tons per acre? How close are you to that?

"We've achieved that with the work we've done with CenUSA, but not with switchgrass. We achieved it with miscanthus. So you're talking 20 thousand kilograms per hectare. With the 'Liberty' switchgrass, we were able to get close to 15,000, not 20,000. We were pretty close, but the miscanthus on the same site was at 30-to-35,000. If you want to get 10 tons per acre of dry biomass, we can get close with "Liberty." We're already there with Miscanthus. We're 50 percent above that."

Where do you see switchgrass agronomic practices in 20 years from now and what advancements need to happen in order to get them there?

"What I would like to see is more of a systems approach to switchgrass, miscanthus too, but especially switchgrass. It's a plant that has mainly been looked at for a hundred years as a forage crop. Then in the 80s, it got some interest as a biomass crop, but it could be both. There are probably ways to manage it for livestock production along with bioenergy production to make farms profitable. A part of it is thinking about multiple purposes for these plants in the various systems that farmers might have. We should also think hard about the ecosystem services that switchgrass provides and start putting value on those. I think there needs to be a more holistic view of valuing what plants like switchgrass bring to agriculture, to communities and to people."



CenUSA Bioenergy White Paper

What was your role with Extension and Outreach objectives?

"I wasn't formally involved in that, but I always have an Extension appointment. I take questions and participate in programming related to forages and bioenergy all the time whenever they come. I think there was a team of about 30 Extension people involved at various levels across the whole CenUSA project. It's kind of a crowded space, so I just kind of stuck to my own part for the most part."

So to the extent you were involved, how was this different from preparing for an article in a scientific journal?

"I think Extension can do certain things that are nice for demos. There was a lot of that done, and that was good, but Extension is a big part of a continuum that starts with creating ideas, testing them with research and publishing the research. That leads to the Extension fact sheets and information for farmers. Sometimes that middle piece gets left out, and people do a run around the science. Extension needs to get back to evidence-based practices where the evidence goes back to rigorous, scientific, peer-reviewed articles, not just doing some farmer demos and small plot work, publishing those results and telling farmers what to do. Those latter approaches don't generally undergo rigorous peer review, so what's really critical is that we should get back to the linear process of making sure that the science is done well, gets peer-reviewed by others and gets published. From there, we extract the Extension publications. Then it's evidence-based and authoritative. That's not just about CenUSA, that's about a lot of other programs in the country."

What's the most important or most interesting facet of your research that you want the interested public to understand?

"I think the potential for a bioeconomy is huge. We can grow tremendous amounts of biomass. It can be tailored through breeding and genetics to a certain extent, then the people who can engineer and modify those materials can make the bioproducts. The potential is there, it's about the political will and financial model."

What work are you looking forward to next after CenUSA?

"We've got this other project where we are using cover crops like rye and comparing them as a biomass production system to corn stover and switchgrass production. We're not only looking at the productivity, but also the environmental performance at the water quality field station. This kind of goes back to my little Extension blurb a minute ago when I was criticizing the process. I'll own it. Here at Purdue, there's a group that talks at great lengths about the virtues of cover crops, yet farmers aren't using them. Some are, but very few are and there is a reason for that. A part of it is economic.

They also talk about the environmental virtues, but most of those are without evidence. What we're doing is seeing that when you grow cereal rye after corn, how much N does it actually trap? How much does it protect groundwater quality? By how much does it reduce greenhouse gas emissions? Then grow their stuff for biomass and compare it to well-known systems like switchgrass, something we've been studying at CenUSA for about seven or eight years now. We are continuing the legacy of CenUSA, but with a twist using cover crops, looking at agronomic and environmental performance and getting the evidence that will help people make decisions, whether this works economically and also for the environment."

Jeff Volenec CenUSA Bioenergy Work Product

Extension and Outreach

- ✓ Test Plots Show How Perennial Grasses Can Be Grown for Biofuels. Rob Mitchell, USDA-ARS. & **Jeff Volenec**, Purdue Univ. (2013). https://cenusa.iastate.edu/files/cenusa_2019_013.pdf

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- ✓ Dierking R.M., D.J. Allen, S.M. Cunningham, S.M. Brouder & **J.J. Volenec**. 2017. Nitrogen dynamics in above and belowground tissues of two Miscanthus × giganteus genotypes under various N fertilization rates. Front. Plant Sci. doi: 10.3389/fpls.2017.01618
- ✓ Dierking, R.M., D. Allen, S.M. Brouder & **J.J. Volenec**. 2016. Yield, biomass composition, and N use efficiency during establishment of four Miscanthus × giganteus genotypes as influenced by N management. Biomass Bioenergy 91: 98-107
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- ✓ Ojeda, J.J., **J.J. Volenec**, S.M. Brouder, O.P. Caviglia & M.G. Agnusdei. 2016. Evaluation of Agricultural Production Systems Simulator APSIM as yield predictor of Panicum virgatum and Miscanthus x giganteus in several US environments. GCB Bioenergy. 9: 796–816. doi: 10.1111/gcbb.12384

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