INL/EXT-19-55217

Regional Feedstock Partnership 2019 Workshop Report

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July 2019

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operated by Battelle Energy Alliance

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Regional Feedstock Partnership
2019 Workshop Report

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Prepared for the U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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Executive Summary

The U.S. Department of Energy (DOE) and the Sun Grant Initiative began the Regional Feedstock Partnership (RFP) in 2007 primarily to address information gaps associated with sustainably and reliably producing a billion-tons of biomass annually by the year 2030 for the U.S. bioenergy industry. The culmination of these efforts were reported in the Sun Grant/DOE Regional Feedstock Partnership Final Technical Report.[1] The same biomass resources used to support these yield and sustainability efforts included analytical characterization data representing biomass quality. Considerable effort has been put into collection, harmonization, and archival of the analytical data, metadata, and physical samples associated with the thousands of samples collected from the RFP field trials. This data provides a unique opportunity to understand the impacts of agronomic and forest production practices, as well as environmental factors, on biomass material attributes relevant to bioenergy production. To more efficiently develop these relationships, this workshop was held to bring together the experts who conducted the RFP field trials and the biomass attribute data analysts.

The objectives of the workshop included the following:

- Enable face-to-face interactions with field trial experts, allowing for insights into the species and field trials themselves that are not obvious looking at data alone
- Fill in metadata and analytical gaps from the RFP for future analyses
- Share results from analysis of RFP biomass properties for each species along with associated field experiment observations/results
- Discuss the potential to develop biomass quality maps
- Discuss preparation of peer-reviewed publications for each species
- Discuss outlines for a comprehensive summary report on the evaluation of RFP biomass material attributes for quality determination, focusing on the results of peer-reviewed publications and analysis of compiled RFP biomass attribute datasets

[1] Owens VN. Sun Grant/DOE Regional Feedstock Partnership: Final Technical Report. South Dakota State Univ., Brookings, SD (United States); 2018, p. 255.

Participants

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Workshop Agenda

Monday, July 15, 2019

Energy Systems Laboratory (ESL), 750 MK Simpson Blvd., Idaho Falls Room B102

8:45 Introductions .....

9:00 Opening remarks, project & meeting objectives ..... Mark Elless, DOE BETO
Rachel Emerson, INL
Vance Owens, SDSU
Amber Hoover, INL

9:30 Miscanthus ..... Rachel Emerson

11:00 Biomass quality assessment & analysis ..... Nourredine Abdoulmoumine, UT

11:30 Switchgrass ..... Amber Hoover

12:30 Working Lunch..... BFL Data Qualification, Rachel Emerson

1:45 Sorghum ..... Rachel Emerson

2:45 Energycane ..... Amber Hoover

4:00 CRP Mixed Grasses ..... Amber Hoover

Tuesday, July 16, 2019

Energy Systems Laboratory (ESL), 750 MK Simpson Blvd., Idaho Falls Room A106

8:30 Willow/Hybrid Poplar ..... Rachel Emerson

9:30 Potential to develop biomass quality maps .....

10:45 Summary report on RFP biomass property evaluation for quality/publications .....

11:30 RFP physical sample and data archive .....

Biomass Presentations Overview

The presentations for each biomass species included a summary of the samples, metadata, and analytical data that were available. The purpose for this approach included the following objectives:

- Identify the gaps in information that could be filled now or in the future
- Promote discussion on specific reasons for gaps, e.g., no plant growth, significant weather events, etc.
- Draw attention to the impacts that data gaps might have on statistical designs

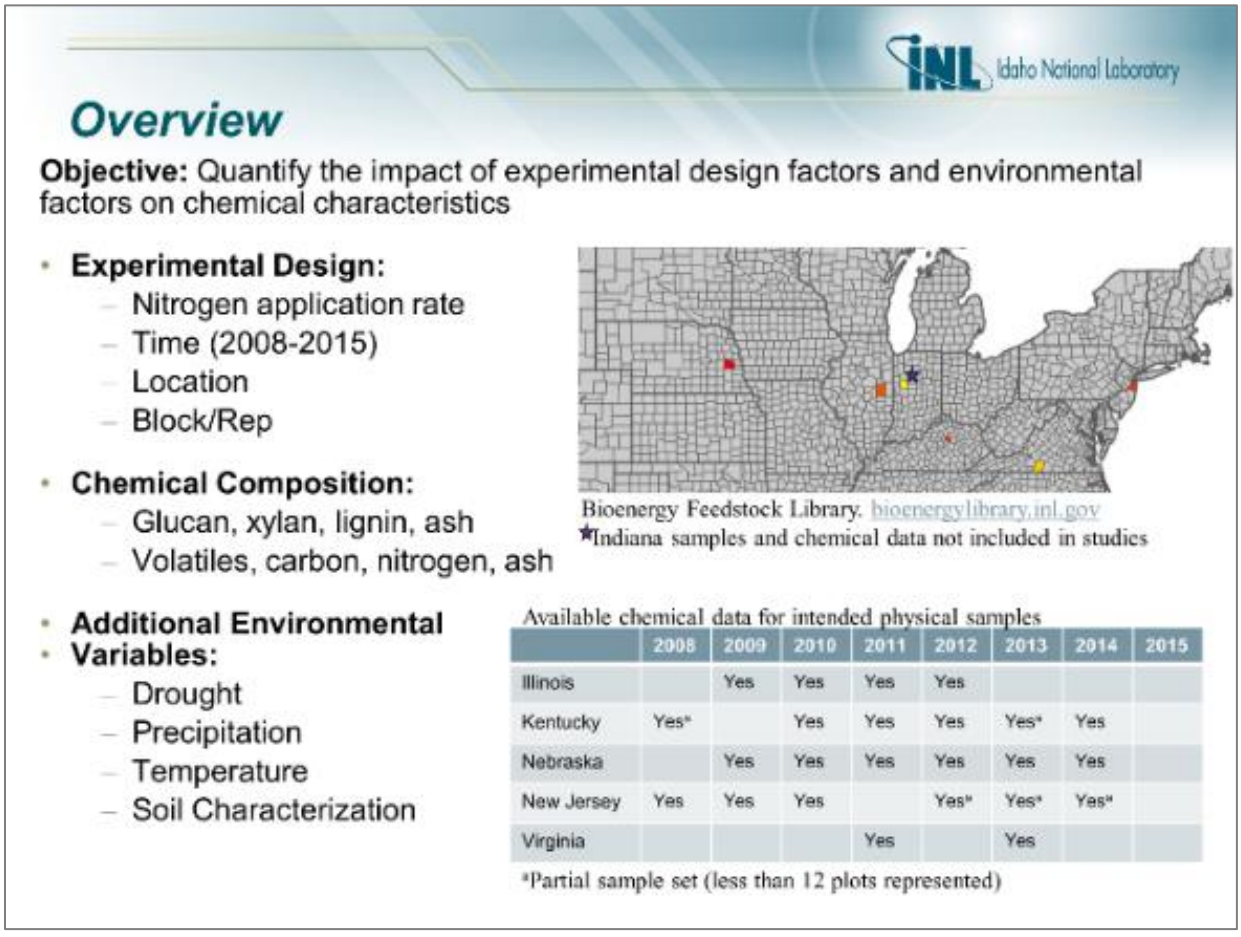

Figure 1. Example of overview slide from *Miscanthus* presentation

Each presentation also laid out the statistical designs for both the experimental parameters generated for each field study and the proposed environmental parameters. Preliminary statistical analyses and regressions were shown based on these designs. The aim for this exercise was to meet the following objectives:

- Verify statistical design and approach

- Promote discussion for identification of additional environmental factors and model designs to be considered
- Demonstrate the potential for the environmental factor models to support generation of biomass quality maps
- Identify factors that were unaccounted for in the results that might explain observed trends

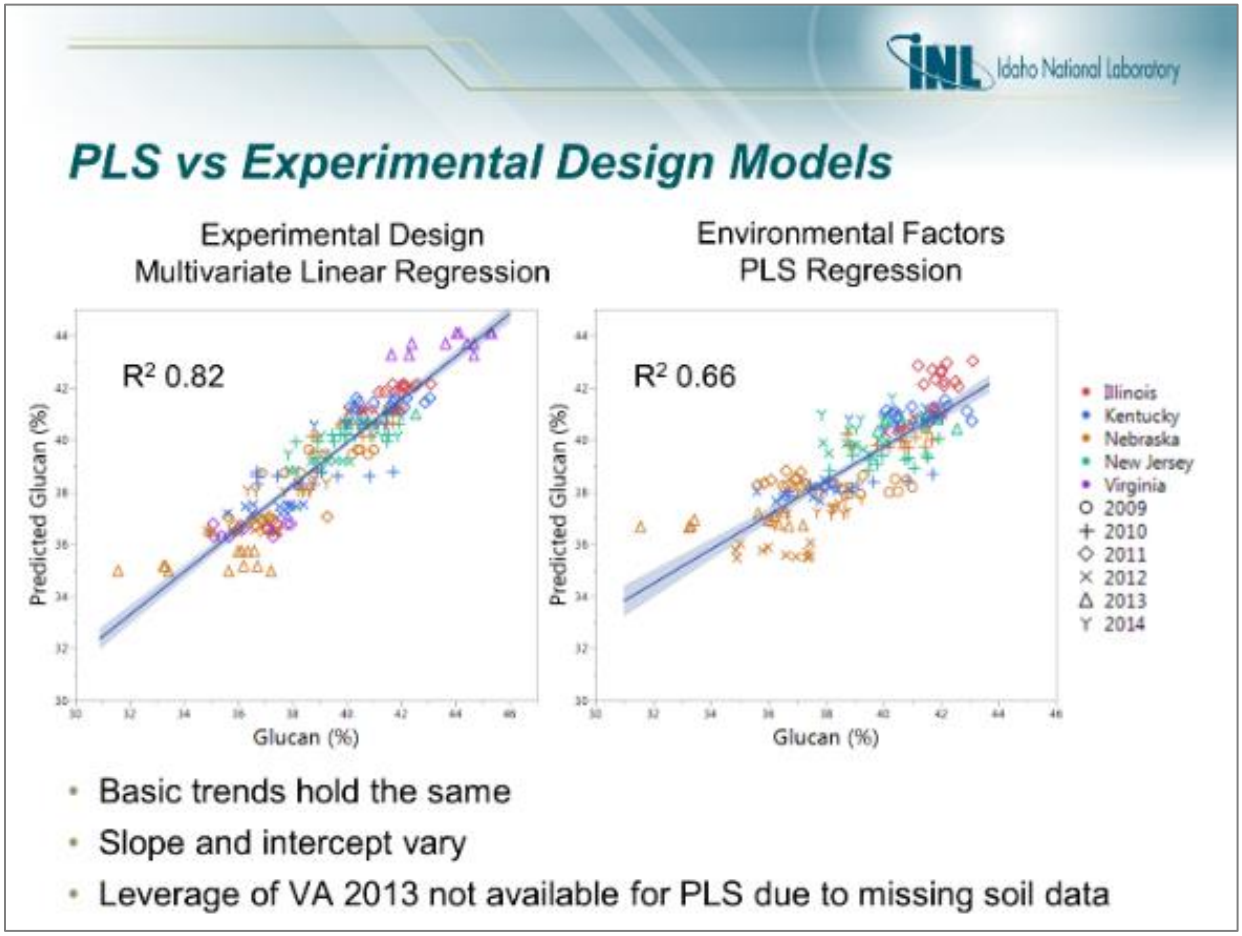

Figure 2. Comparison of PLS models for *Miscanthus* glucan predicted using the experimental design (i.e., nitrogen application rate, year, location) and environmental explanatory variables from *Miscanthus* presentation

Highlights:

- *Miscanthus*: Very promising preliminary results for environmental factor based predictive models for biomass material attributes. Environmental variables including drought factors, precipitation, temperature, and soil factors could explain between 61 and 95% of the variability for the 8 chemical factors assessed. Promoted discussion

for opportunity to improve models through addition of more environmental and other relevant explanatory variables.

- *Switchgrass*: Models were separated by location and subsequently cultivar and ecotype because most locations were planted with a different cultivar. Results were promising with environmental variables, nitrogen application rate, and dry biomass yield being able to explain 46 to 97% of the variation in glucan, xylan, lignin, volatiles, carbon, and nitrogen.
- *Sorghum:* Models need to include or be separated by either genotype or sorghum type. Soil could be considered in the future; however, because it is an annual crop, sorghum trials were conducted in different fields each year, thus there was no plot level soil data available for analysis.
- *Energycane:* Genotypes were modeled separately for three locations in the southeast U.S. using explanatory variables of drought, precipitation, temperature, and winter conditions, which are all known to impact yields, grand growth, and ºBrix. Dry biomass yield was also included as an explanatory variable and models could explain 40 to 87% of the variability in glucan, xylan, lignin, and volatile content.
- *CRP Mixed Grasses:* Due to the complexity of the mixed grass species composition, each site was analyzed separately. Species composition changes over time in Kansas could explain 73% of the glucan variation when harvested at peak standing crop, but very little of the glucan variation if harvested after a killing frost. Environmental explanatory variables could explain 77% of the glucan variation at peak standing crop and 79% of that same variation after a killing frost.
- *Hybrid Poplar:* Analysis was limited due to sample numbers and analytical data collected. Identified opportunities to expand this sample set.
- *Shrub Willow:* Analytical data (collected by Cornell University) is available for a subset of field study samples representing one rotation. Preliminary results are promising but would require more of the RFP rotations to increase relevance.
- Nourredine Abdoulmoumine of The University of Tennessee gave a presentation highlighting the importance of inorganic species in thermochemical pyrolysis reactions.

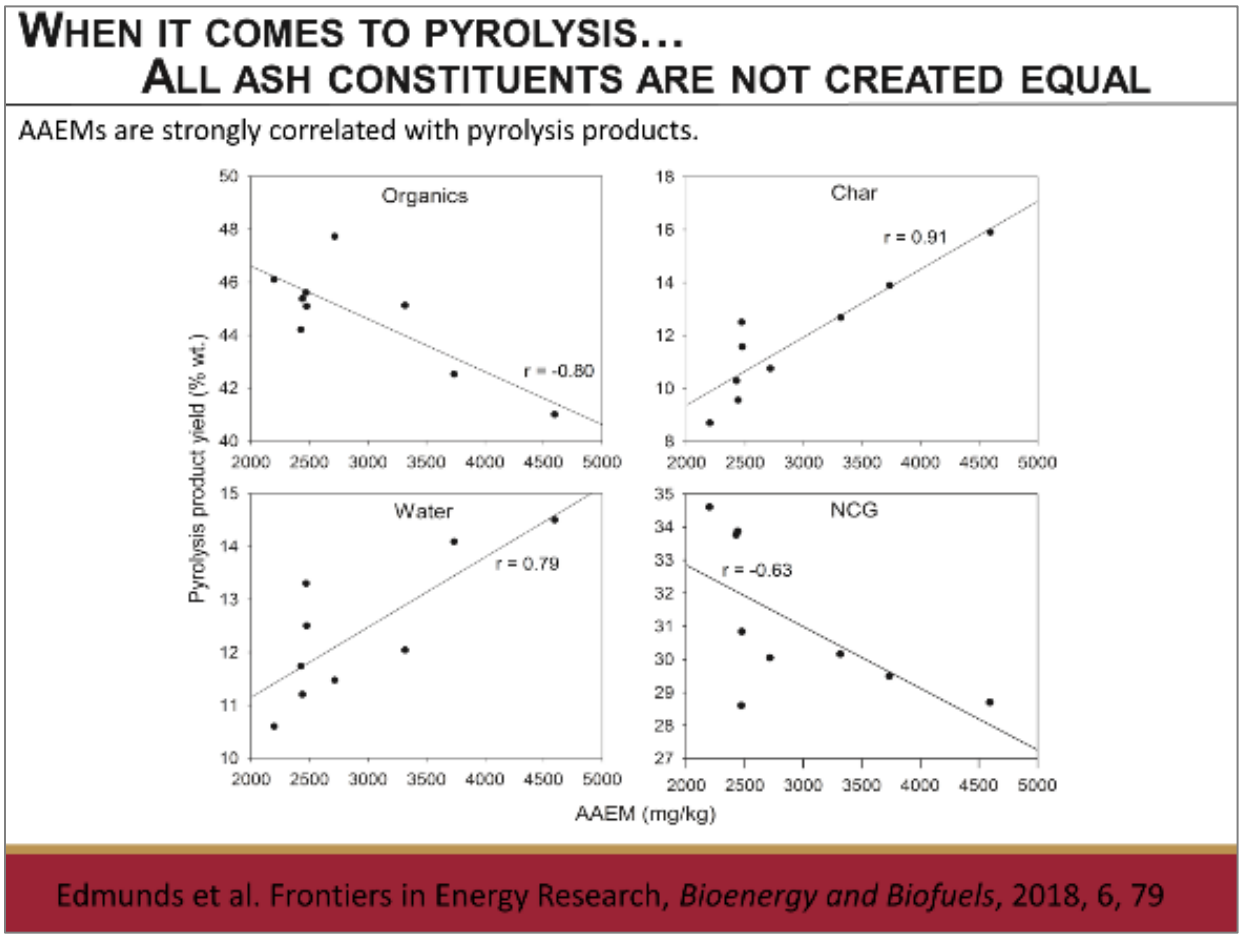

Figure 3. Impacts of ash constituents discussed in presentation by Nourredine Abdoulmoumine of The University of Tennessee

Partnership Feedback Summary

The presentations were well received and led to rich discussions. The partners provided specific information for each biomass species/location, encompassing the goals of the presentations, as stated above, and the overall workshop.

Highlights:

- Using more generalized groupings of the biomass species for environmental models will be more informative and impactful. For instance, models using environmental variables to predict chemical properties of sorghum would have broader application if it was done by sorghum type (biomass versus sweet sorghum) rather than by genotype, which provides limited information as new genotypes are developed. This

same idea can be applied to switchgrass (lowland versus upland), CRP mixed grasses (using functional botanical groups), and energycane.

- Inclusion of information and environmental data will be more effective when based on more detailed information about plant maturity (e.g., leaf expression, flowering, stages of rhizome development).
- The following explanatory variables were suggested for inclusion (with species they weren't already modeled with) in the analyses: dry biomass yield, nighttime temperatures, environmental conditions from the year before, and National Commodity Crop Production Index (NCCPI).
- *Hybrid Poplar:* Limited samples and analytical data were available for this presentation. Tim Volk, Tim Rials, and Brian Stanton identified a large amount of already physically prepared for analysis and archived samples and some potential strategies for analyzing these samples to be included in the RFP data analysis. It was agreed that inclusion of short-rotation woody crops is important.

Biomass Quality & Quality Map Development

Biomass Quality

As biomass quality was a significant component of the meeting there were many discussions around the types of material attributes that dictate quality and their uses.

- What additional biomass material attributes need to be included?
    - Inorganic species
    - Extractives
    - Soluble sugars (specifically for energycane and sorghum)
    - Fiber analysis (hemicellulose, cellulose)
    - Mechanical and physical (e.g., density, crystallinity, etc.) properties
    - Morphology (specifically for woody crops)
    - Carbohydrate/hectare (e.g., glucan/hectare)
    - Material attributes of interest will vary by end user
- What questions we are trying to answer with these biomass material attributes?
    - Informing harvest timing
    - Comparing biomass types
    - Biomass properties coming off of the field
- Who are the end users of this information?
    - Developers of bioenergy projects
    - Academic researchers

Quality Map Development

It was agreed that development of maps of biomass material attributes was a potential outcome based on the preliminary results shown over the course of this workshop. Discussion around the development of quality maps focused on a few key areas:

- Potential users of the maps
    - Use the KDF yield map users as one informative resource
- Linking data to conversion processes
    - Select properties for their importance to conversion processes
    - Display biomass properties in an agnostic way and allow user to interpret how they affect their process
- Identifying the most important information that these maps should provide
    - Potential ranges of variability for biomass properties
    - Future projections of variability based on environmental input
    - Visual distributions of variability in biomass properties
    - Temporal as well as spatial variability
    - Clear descriptions of data inputs to help users interpret resulting maps
- Inclusion and importance of soil data and the limitations of SSURGO data
- Learning from KDF map development and potential future linkages between biomass availability maps and biomass quality maps
- Expansion to datasets outside the RFP (e.g., southern pine cooperatives)

Action Plan and Future Work

Publications

A plan was discussed to produce publications for the five herbaceous species and shrub willow through collaboration between INL and the RFP institutions.

More information is needed for the hybrid poplar to complete a publication. Subsequent conversations and meetings are planned between INL, The University of Tennessee, SUNY-ESF, and GreenWood Resources to determine what options are available.

RFP Summary Report

A preliminary outline was proposed for the RFP Summary Report focusing on biomass material attributes. The summary report will be developed following the planned publications.

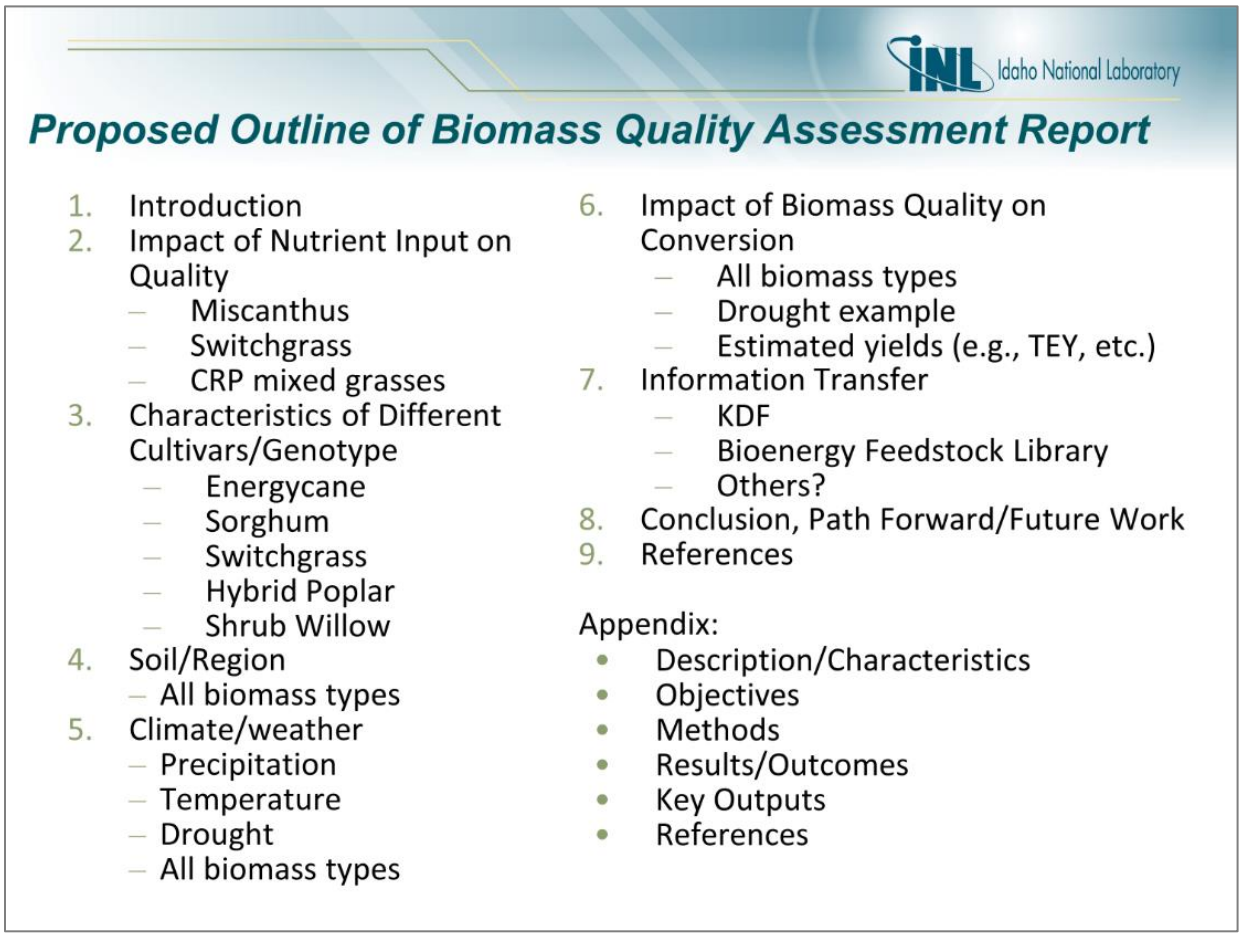

Figure 4. Proposed outline for RFP Summary Report focused on variability in biomass material attributes

Quality Mapping Tool Development

Based on the positive response for the potential of quality maps of biomass material attributes using the available RFP datasets and statistical approaches, preliminary quality maps will be formed in FY20 using at least one of the biomass types (*Miscanthus* and/or Switchgrass) and historical and future predicted weather patterns to demonstrate the feasibility of the approach.

This work will inform experiments and data collection to increase the impact of future quality maps. The team emphasized the need for additional experiments designed specifically to provide data to refine the quality mapping approach.

Physical Samples and Data Archive

Plans were made to display the RFP data and datasets in the Bioenergy Feedstocks Library (BFL) for ease of use by other researchers.

Some ideas were discussed on how archival of samples from similar type projects (specifically, the recent *Affordable and Sustainable Energy Crops FOA*) should be addressed based on what was learned from the RFP project. Ideas included:

- INL providing packaging and labels to institutions for sample collection
- Clearly defining expected amounts and formats for samples
- Providing word documents or spreadsheets requesting specific metadata parameters for each sample.

Appendix A: Data Qualification Survey Results

The Bioenergy Feedstock Library (BFL) (https://bioenergylibrary.inl.gov) is currently being used as the repository for the physical and analytical data presented during this workshop. The biomass attribute maps developed from this data will also be posted as a data visualization resource within the BFL. Recent BFL development work has focused on having a more systematic way to provide information about data quality for biomass datasets stored in the BFL. The goal behind this would be to provide methods for researchers and data users to quickly evaluate data quality and determine if it meets the data quality standards they are looking for. A set of data qualification criteria was developed prior to the RFP workshop. The workshop attendees were asked fill out a short survey to assess to importance and value of each of the proposed data qualification parameters. Each question had the following response options:

"Usefulness of [data qualification category] (1: being not useful, 5: being very useful).

1 2 3 4 5

Are there other aspects to consider about [data qualification category]?"

The data qualification categories were the following:

Methodology: Is this methodology used for this specific analytical measurement(s) standard, primary and/or generally accepted for the sample type being analyzed?

Standards: Are standards and/or controls data readily available via additional files, citations, data points, or comments associated with the data point?

Replication: Is there data on replication available via additional files, citations, data points, or comments associated with the data point?

Specification: Does the data point meet the analytical method-specific specifications for precision, accuracy, experimental conditions, etc.?

Preparation: Is sample preparation information available via historic (parent) samples, metadata, additional files, citations, data points, or comments associated with the data point consistent with the required methods?

History: Is there a parent/child lineage or metadata associated with this sample that tracks the specifics of the sample origination? A historical lineage of the samples can provide more accurate information for informing the analytical data results and quality.

Primary Qualifier: Was this a 1st person qualification? In other words, is the researcher or qualified member from a research group qualifying the data the same person who collected and entered the data into the BFL?

The results of the survey are given below (Fig. A1). Overall information on standards and sample history had the lowest average scores of 3.6 (of 5) and methodology had the highest average score of 4.7. Every category was given a 5 by at least one reviewer. Standards and replication were each given the lowest score of 2 by at least one reviewer each.

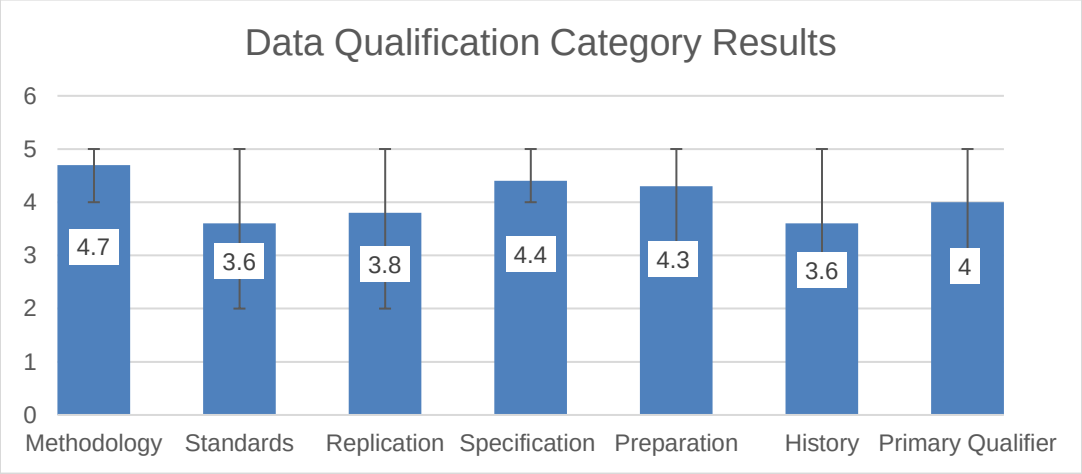

Figure A1. Data qualification survey results based on quantified importance of each of the seven data qualification categories proposed