

WBS 1.2.2.2 - Bioenergy Feedstock Library

<http://bioenergylibrary.inl.gov>

2017

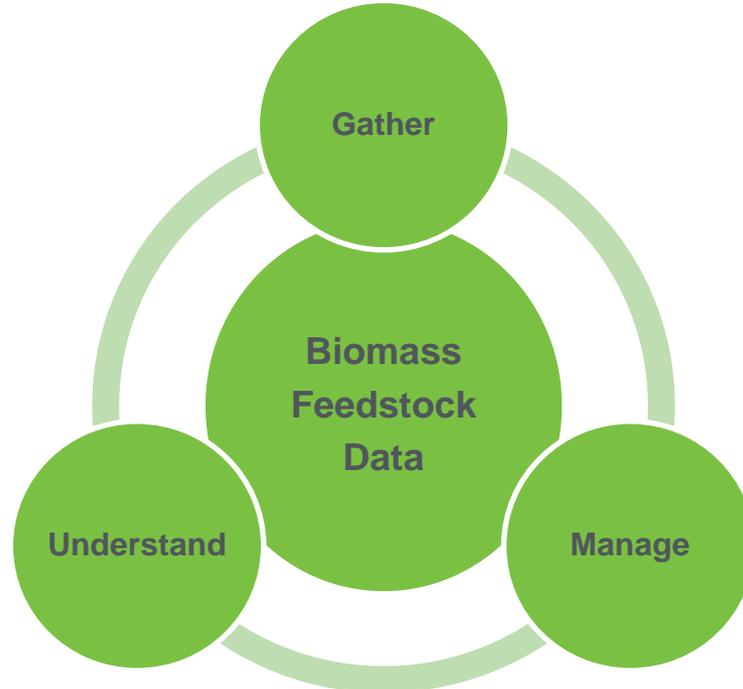
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Victor Walker

Idaho National Laboratory

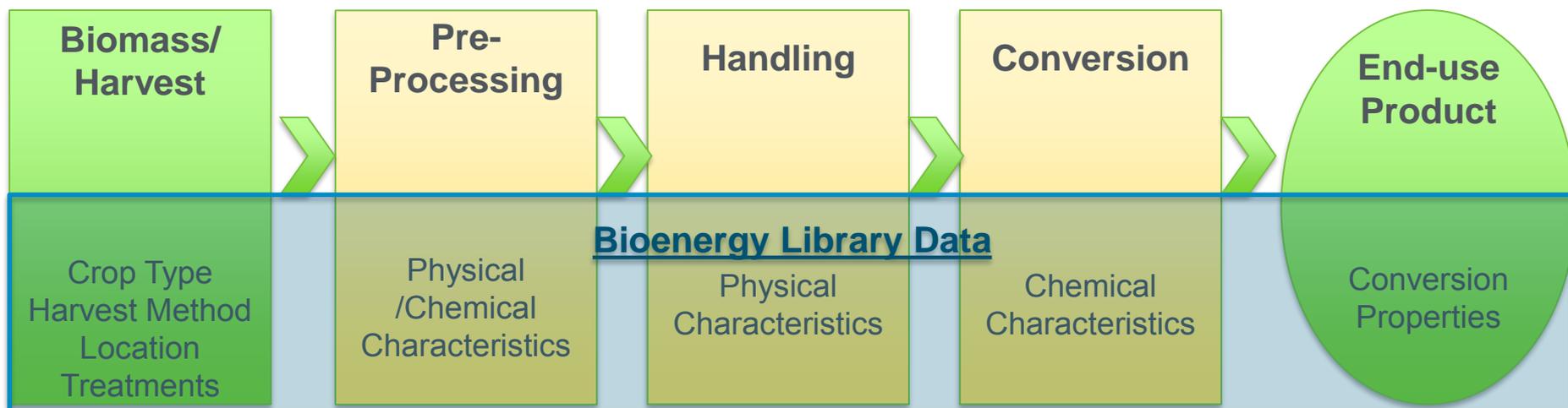
Goal Statement

- Objective
 - Create central repository for biomass/feedstock **samples**, **sample information** and **research data**
 - **Gather**, **manage**, and **understand** biomass/feedstocks and data to advance research and industry
 - Provide **infrastructure** and **tools** to interrogate trends, variability, and relationships among biomass characteristics.
 - Understanding of biomass and feedstocks is critical to bioenergy research and industry
 - Repository of data is critical to understanding biomass and feedstocks



Goal Statement

- History
 - Library initially developed as an internal sample tracking system
 - Deployed in 2010 for internal users and broader user base in 2012
 - Public accessible tools deployed in 2015
- Relevance
 - Chemical and physical characteristics impact every aspect of the supply chain
 - Understanding variability impacts and correlations for each stage is critical
 - Supports several BETO projects (such as biomass grading) and part of FCIC
- Context



Quad Chart Overview

Timeline

Based on Merit Review

- Project start date: 10/01/2014
- Project end date: 09/30/2017
- Percent complete: 75%

Budget

	FY 15 Costs	FY 16 Costs	Total Planned Funding (FY 17-Project End Date)
DOE Funded	\$960.2K	\$2.45M	\$752.3K

*budget in 2016 included Regional Feedstock Partnership Contracts

Barriers

- Ft-G, Feedstock Quality and Monitoring
- Ft-J, Biomass Material Properties
- Bt-B, Biomass Variability

Partners

- Regional Feedstock Partnership Collaborators (44)
- University Partners (ISU)
- Lab contributors
- Commercial providers (16)
- Feedstock Conversion Interface Consortium (FCIC)

1 - Project Overview

Parent Samples

- Harvest
- Stored
- Intermediates



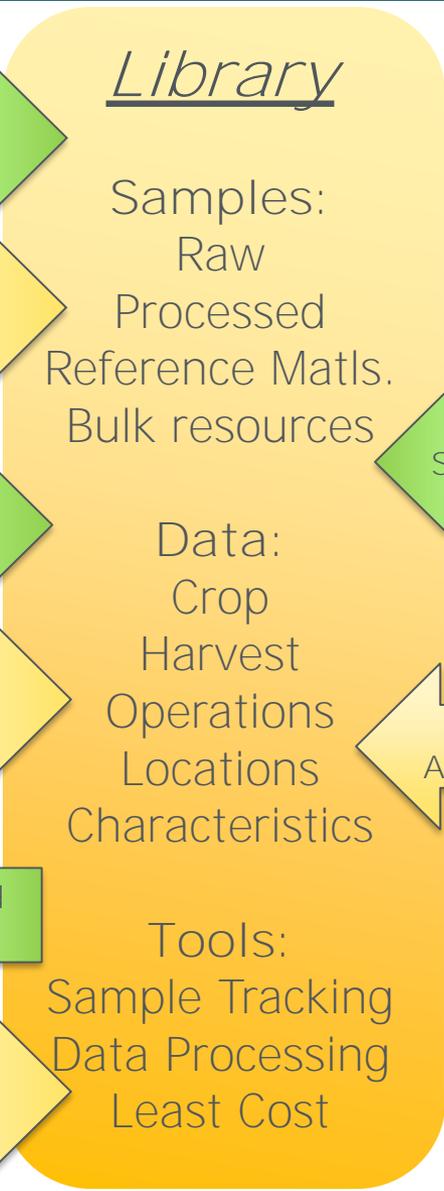
Process Demonstration Unit

- Drying
- Grinding
- Densification
- Splitting



Analytical Lab

- Composition
- Ash
- Prox. & Ult.
- Elemental

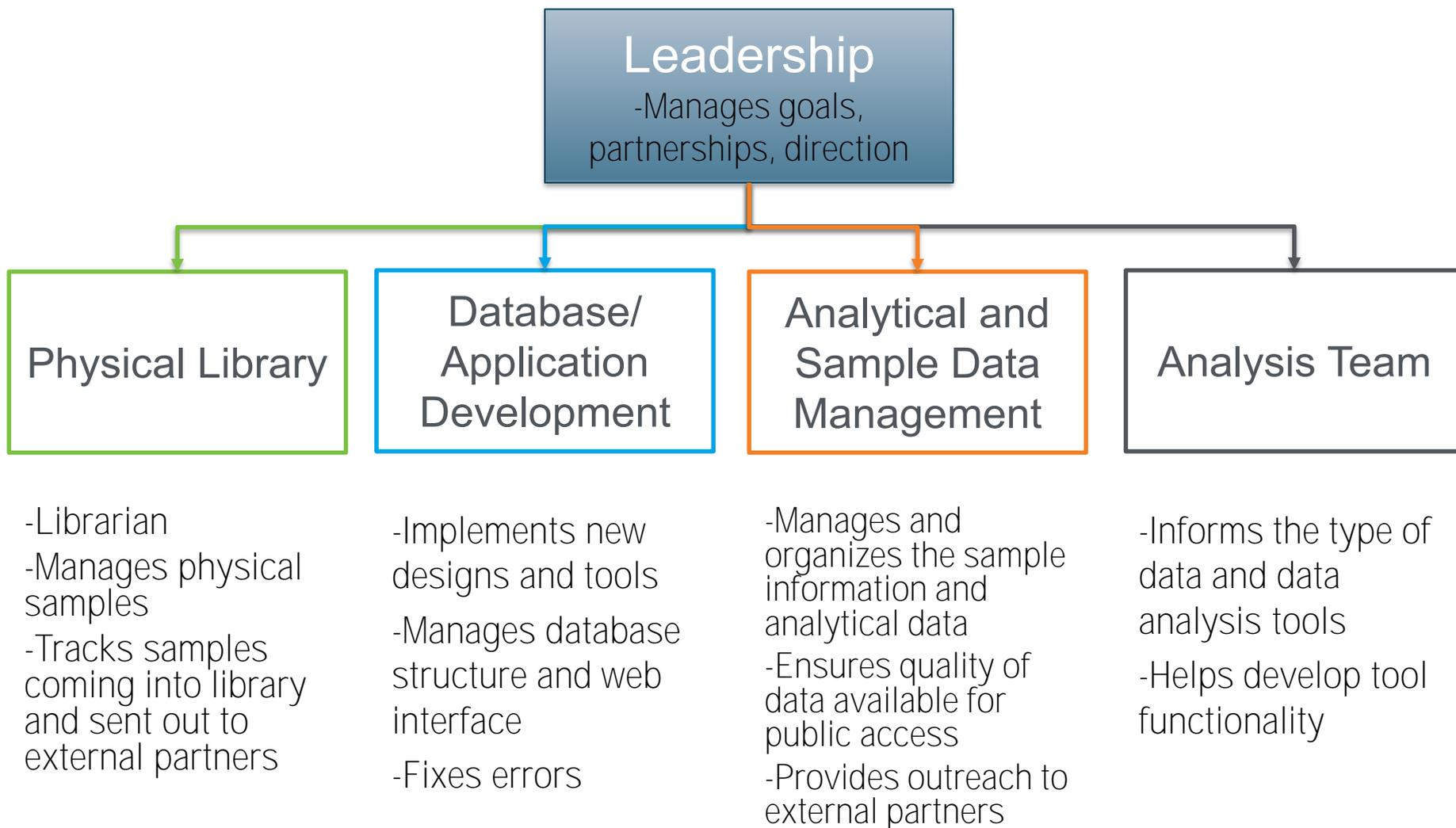


Regional
Feedstock
Partnership
National Labs
Universities



Industry
International
Researchers
Other Gov.
Researchers

2 – Approach (Management)



2 – Approach (Technical)

Gather

- Populate Library with relevant biomass and feedstock [samples and attribute data](#) from a wide variety of sources
 - Regional Feedstock Partnership
 - Industrial partners and other internal/external projects

Manage

- Provide a [secure, useable database](#) to store sample and data for internal and external projects
 - Gather data from partner projects
 - Develop and manage database and web application
 - Work with researchers to gather and track their work

Understand

- Investigate data and provide [data interrogation tools](#) and methods to gain knowledge and support from data
 - Tools and methods to understand data
 - Data mining and visualization
 - Industrial perspective/input

2 – Approach (Technical)

Challenges

Comprehensive Data Set

- Critical to have large number of reliable, rich data sets for a variety of biomass and feedstock resources
- Need multiple contributors
- Maintain quality control on all data in Library

Metrics:
Data
Tools
Users

Reliable Answers

- Understand the questions and potential uses
- User-friendly and valuable tools and resources that make sense of raw data in reliable ways
- Tools that are relevant to the industry



Visibility

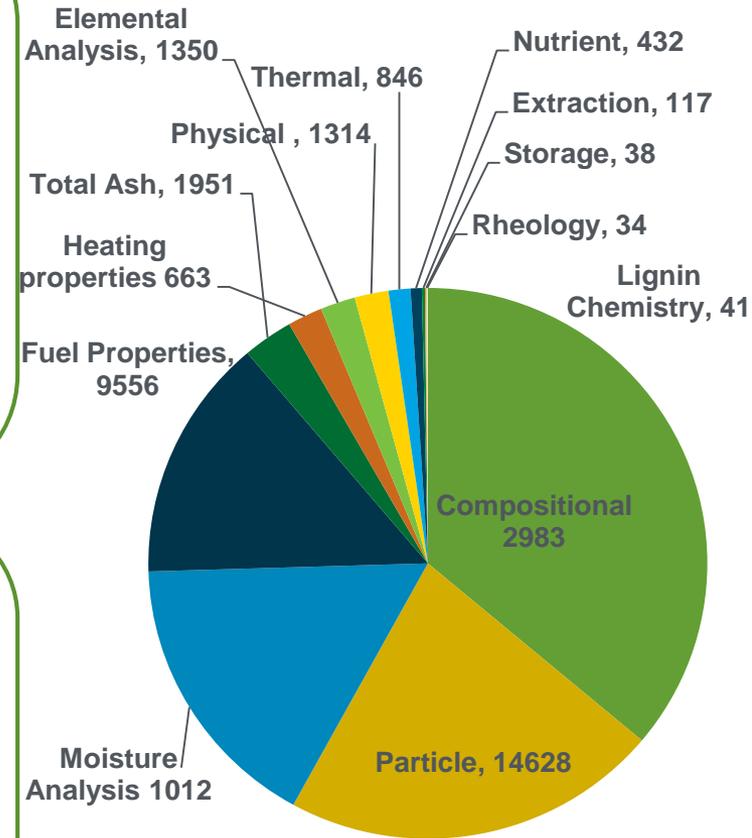
- Resources that are visible and usable by a large audience
- Methods to encourage researchers and industry to participate and contribute

3 – Technical Accomplishments

Data Collection

- Over 62,000 samples tracked
 - (23,000 originals + children)
- Over 1,200,000 sample information data points
- Over 65,000 analysis data points
- Over 80 projects (tracking unique datasets)
- ~120 Contributors (Industry, academia, etc.)
- Over 100 biomass types

- Sample information
 - Crop type, location, harvest information, field information, etc.
- Analysis information
 - Chemical composition, fuel properties, ash, conversion process characterization, etc.
- Operations
 - grinding, pelleting, leaching, storage, conversion, etc.



of analysis data points by type

3 – Technical Accomplishments

Go/No Go (FY16 Q2)

Make characteristic data available publicly.

Objectives Met



Go/No-Go Criteria:

- Demonstrate improved availability of relevant data to research partners and the public by [increasing generally available characterization data](#) and [strengthening the analytical tools for external use](#).
- Make available to the public a minimum of one comprehensive data set, which includes characterization data representing multiple crops and regions across the USA, and demonstrate a minimum of two additional tools that draw on the Library datasets to evaluate feedstock characteristics for research.

3 – Technical Accomplishments

Re-design and Outreach

Move from internally focused tool for tracking samples and data...



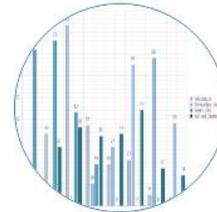
About Us

The Library is sponsored by DOE and hosted at Idaho National Laboratory.



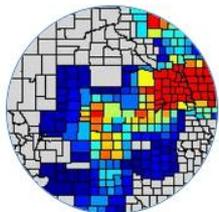
Biomass Info

Review reference biomass and request samples for research.



Attribute Graphs

Find detailed graphs about feedstock qualities.



Least Cost Formulation

Explore the availability of crops based on key variables.



Analysis Summary

Get a quick glimpse of the characteristics of thousands of biomass samples in a single table.



Blend Prediction Tool

Simulate characteristics of biomass blends based on component characteristics.

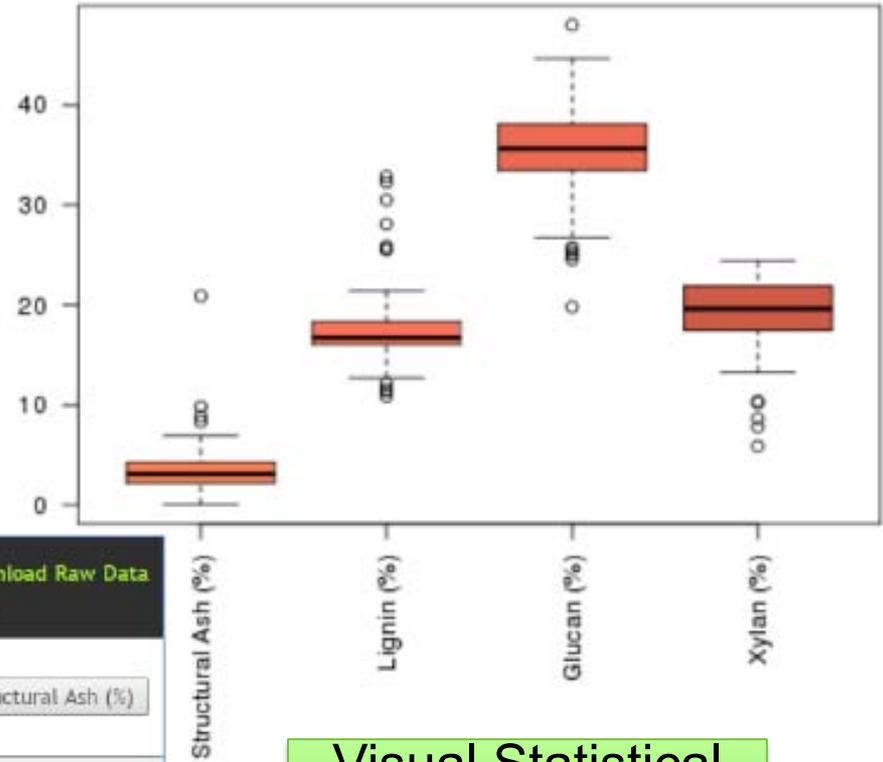
...to a publicly accessible collaboration tool for integrated industry research and knowledge communication

bioenergylibrary.inl.gov

3 – Technical Accomplishments

Tools – Attribute Graphs

- Publicly and privately available aggregate Information
 - Quality reviewed for applicability
- Targeted search
- Overview and detailed statistics
- Exportable information and data



Visual Statistical Analyses

Attribute	#Entries	Min Value	Max Value	Mean	Standard Deviation	Download Raw Data Set
Compositional Characterization, Wet Chemical (NREL/TP-510-48087), Structural Ash (%)	56	0.05	20.90	3.60	3.09	Structural Ash (%)
Compositional Characterization, Wet Chemical (NREL/TP-510-48087), Lignin (%)	56	10.87	32.86	18.05	4.70	Lignin (%)
Compositional Characterization, Wet Chemical (NREL/TP-510-48087), Glucan (%)	56	19.81	47.99	35.31	5.53	Glucan (%)
Compositional Characterization, Wet Chemical (NREL/TP-510-48087), Xylan (%)	56	5.90	24.39	18.80	4.18	Xylan (%)

Data Easily Exported

3 – Technical Accomplishments

Tools – Attribute Overviews

- Displays summary of samples user is authorized to see
- Demonstrates averages and number of samples tested

Summary of Analysis for All Crop Types

The tool generates an overview of the Liberty analysis results, displaying averages of all analysis performed across all crop types. The results are based on those samples that you are authorized to see and may take an extended time to load.

Crop Type	Ash (%; N...	Total Extra...	Glucan Fro...	Xylan (%)	Lignin (%)	Total Ash (%)
Alpine Fir						
Arundo Do...						
Blend						
Bunchgrass						
C&D Waste						
Corn Cob						
Corn Stover						

Color key for number of analyses:

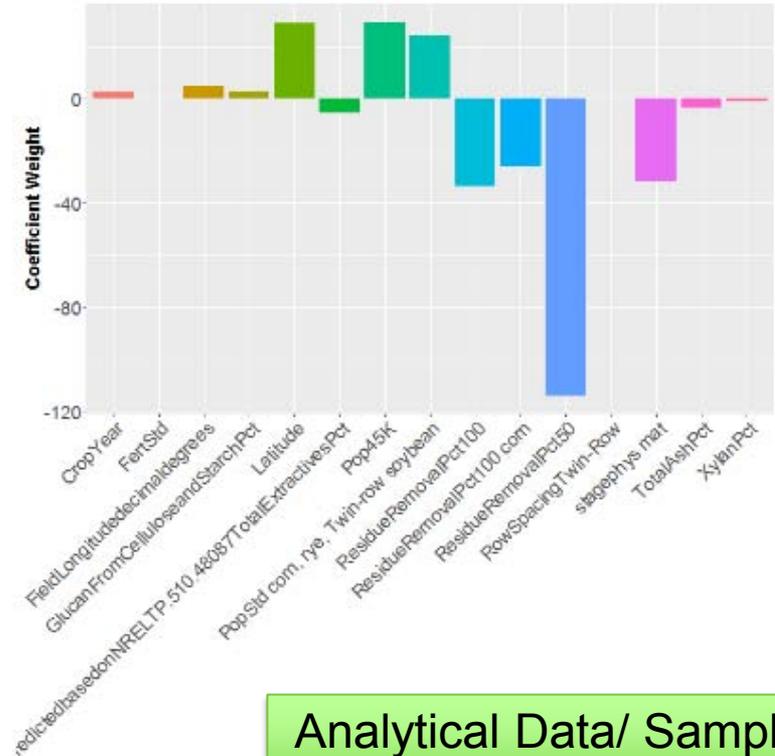
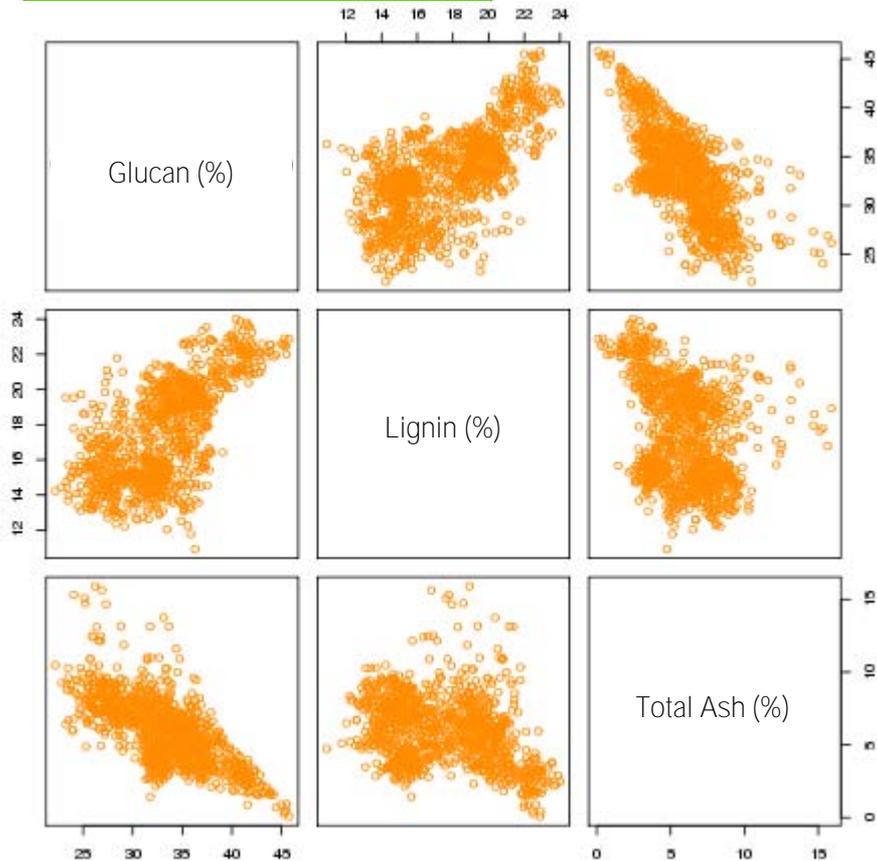
0	7	14	21	28	36	43	50	57	65	72	79	86	93	101	1
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3 – Technical Accomplishments

Tools – Variability Data Mining

- Finds correlations in the data associated with selected analytical data.

Analytical Data Correlation Graphs



Analytical Data/ Sample Information Correlations

3 – Technical Accomplishments

Tools – Blend Prediction Tool

- Allows for predicted blend quality attributes based on averages of Library data

Select Blend

Select Quality Data

The screenshot shows the 'Blend Prediction Tool' interface. On the left, under 'Select analysis type for blend:', a list of materials is shown on the left and a table on the right. The table lists 'Corn Stover' (50.00), 'Paper' (10.00), and 'Switchgrass' (40.00). On the right, under 'Select Quality Data', a search bar and a tree view of analysis types are shown. The tree view is expanded to 'Fuel Properties Characterization' and then to 'Calorific Analysis (ASTM D 5865-10a)', where 'Gross Calorific Value (HHV): BTU/lb' is selected. Below this, a green box contains the text 'Blend Analysis Prediction Results: 50% of (Corn Stover) 10% of (Paper) 40% of (Switchgrass)'. At the bottom, a table displays the results for this blend.

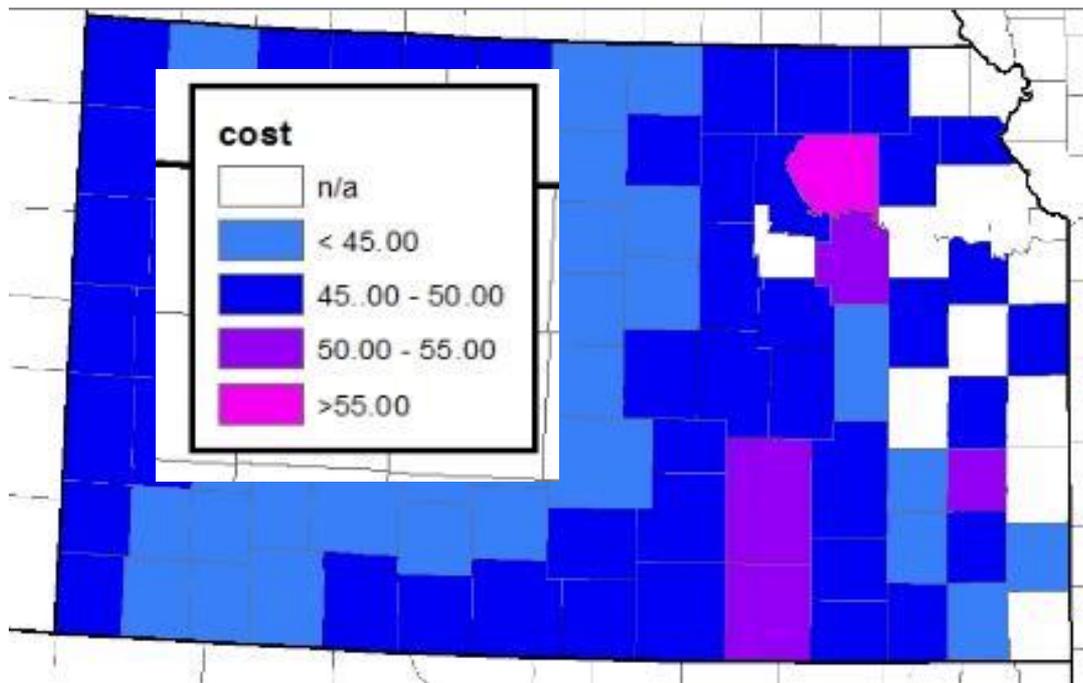
Blend Name	Analysis Type:	Fuel Properties Characterization
	Subtype:	Calorific Analysis (ASTM D 5865-10a)
	Data Point:	Gross Calorific Value (HHV): BTU/lb
50% of (Corn Stover) 10% of (Paper) 40% of (Switchgrass)	# Samples	68
	Avg	7877.78
	Min	6862.32
	Max	8571.55

View Results

3 – Technical Accomplishments

Tools – Least Cost Formulation Enhancements

- Allows for cost estimates for blends based on distance, volume and quality constraints



Estimated county level cost of formulated **blends** of switchgrass, corn stover and wheat straw **meeting quality** (glucan and ash) and **volume** (800K dry tons/yr) specifications in Kansas.

*Cost estimates currently only include farmgate and transportation

3 – Technical Accomplishments

Users - Biomass Reference Material

- 8 Biomass materials in bulk
 - Fully characterized and available for request
- Examples:
 - University of Kentucky – Lignin research
 - University of Cincinnati – Fundamental conversion research
 - Louisiana Tech – Organosolv research
 - University of Delaware – NSF research

Automated Request Process

To request biomass for research purposes

Full Name:

E-mail Address:

Phone Number:

Shipping Address:

Institutional Affiliation:

Blend:

Crop Type Amount

Biomass Info

The Bioenergy Feedstock Library hosts characteristic data from... This page highlights a selection of the Library's crop types. Same characteristics at INL for use in research applications. Physical Samples available for research purposes.

Easily Accessible

[Request Biomass Samples](#)



Corn Stover

Date Shared PDF (Download): 02-10-2016

Corn stover is the most common crop for bioenergy research. Corn stover, an agricultural by-product, consists of the leaves and stalks of corn plants left in a field after harvest. It can be harvested with the chaff of the



Switchgrass

Date Shared PDF (Download): 02-10-2016

Switchgrass is a native warm-season perennial grass that can thrive in a variety of climate conditions and soil types. It can be grown on land that is not suitable for row crop production. It stores carbohydrates in its stems, roots, and

Fully Characterized

Switchgrass

Pedigree

Institution: Oklahoma State University
 Location: Garvin County, OK
 Cultivar: Alamo

Harvested: 2012
 Received at INL: 2013
 Sample Preparation: Ground to pass through a 1-inch sieve using a Vermeer BG480 grinder

Composition

Table 1. Chemical composition^a of Reference Switchgrass

%Structural Ash	%Extractable Inorganics	%Structural Protein	%Extractable Protein	%Water Extracted Glucan ^b
1.88	2.07	1.51	0.54	2.28
%Water Extracted Xylan ^b	%Water Extractives Others	%EtOH Extractives	%Lignin	%Glucan
0.09	6.68	2.68	16.24	33.21
%Xylan	%Galactan	%Arabinan	%Acetate	%Total
21.65	1.43	3.27	3.07	96.60

^aDetermined using NREL "Summative Mass Closure" LAP (NREL/TP-510-48087)
^bDetermined by HPLC following an acid hydrolysis of the water extractives

3 – Technical Accomplishments

Users - Sample Management

- Allows users to explore sample details and relationships. Data can be exported and examined as needed.

Search for Specific Samples

Perform Group: Export Sample Information Export Analyses Export Ancestry

Drag a column header and drop it here to group by that column

Page size: 100

	Analysis	Hierarchy	Files	GUID Identifier				
<input checked="" type="checkbox"/>	<input type="checkbox"/>	View/Edit			0	6c28c4d9-13fa-6144-93c7-10fcb184c1a4		
<input type="checkbox"/>	<input type="checkbox"/>	View/Edit			0	b28fe94a-1b42-1540-890a-883083179def	Miscanthus	Georgia
<input checked="" type="checkbox"/>	<input type="checkbox"/>	View/Edit			0	2d67acc5-9bae-e14e-927c-aacc4d9e1264	Hybrid Poplar	Oregon
<input type="checkbox"/>	<input type="checkbox"/>	View/Edit			0	8743f470-05ae-1043-9673-96172a64cc2d	Hybrid Poplar	Oregon
<input checked="" type="checkbox"/>	<input type="checkbox"/>	View/Edit			0	0715c779-19ac-0546-b189-e2cdd0bba1cc	Corn Stover	Iowa

Visualize Sample Relationships

Property	Value
Date Collected	Not Specified
Collector	Not Specified
Consumed	Not Specified
Operation	Split
Location	ESL-B110 Bench C---
Current Amount	0.00 gal
BT16-Resource Category	Agricultural Resource
BT16-Resource Sub-Category	Energy Crop (Herbaceous)
City	Tifton

Export All Information

Room	CropType	Sample #	State	Crop Year	City	Harvest Date
B110 Bench	Miscanthus	2 mm Split-1	Georgia	2014	Tifton	1/21/2014
	Hybrid Poplar	2 mm Split-6	Oregon	2013		11/21/2013
B110 Mair	Corn Stover	Ground RM - 3d	Iowa	2011		Fall 2011
E101 Libra	Switchgrass	Split C8-1b-1	Oklahoma	2012		7/1/2012

3 – Technical Accomplishments

Current Work – Enhance User Research Collaborations

- Introduce citations and references
 - Encourage participation
 - Create Connections
- Improve project management and sample upload process
 - Ease contribution
- Improve usability and help
- Improve ability to group and examine data

Example:

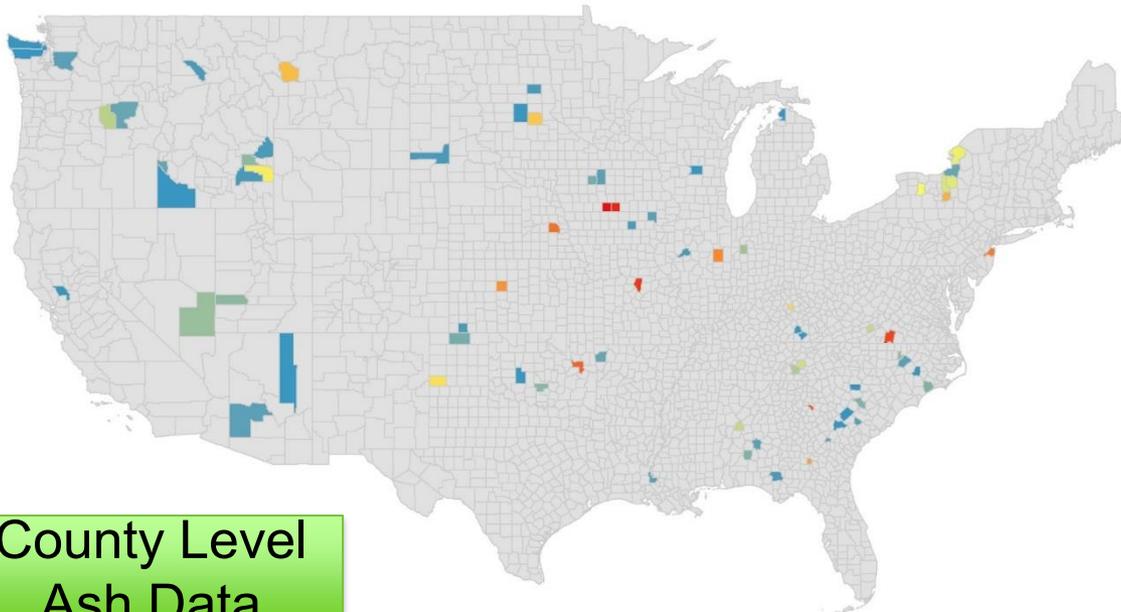
Iowa State University - Biomass Crop Production Lab presented on Library at American Society of Agronomy, Crop Science Society of America and Soil Science Society of America 2016 meeting

“Bioenergy Feedstock Data — how do we learn from it”

4 – Relevance

- Critical input to biomass grading
- Data input to State of Technology (SOT)
- Key component data resource for BETO projects
- Crucial to understanding biomass variability and its impacts

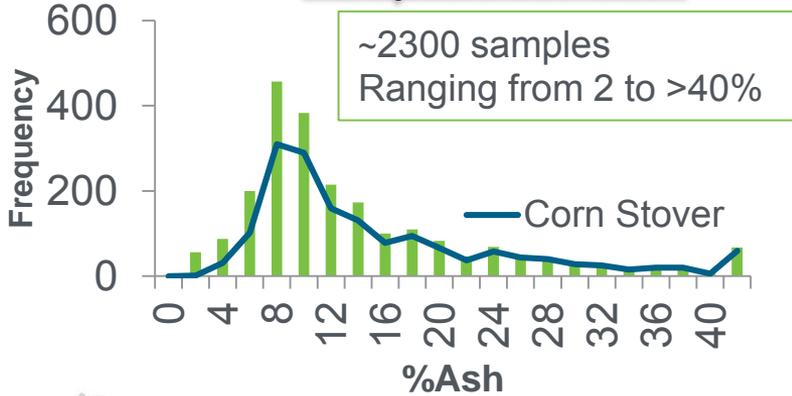
Total Ash Samples by County (2007-2016)



County Level Ash Data



Financial Impact of Ash

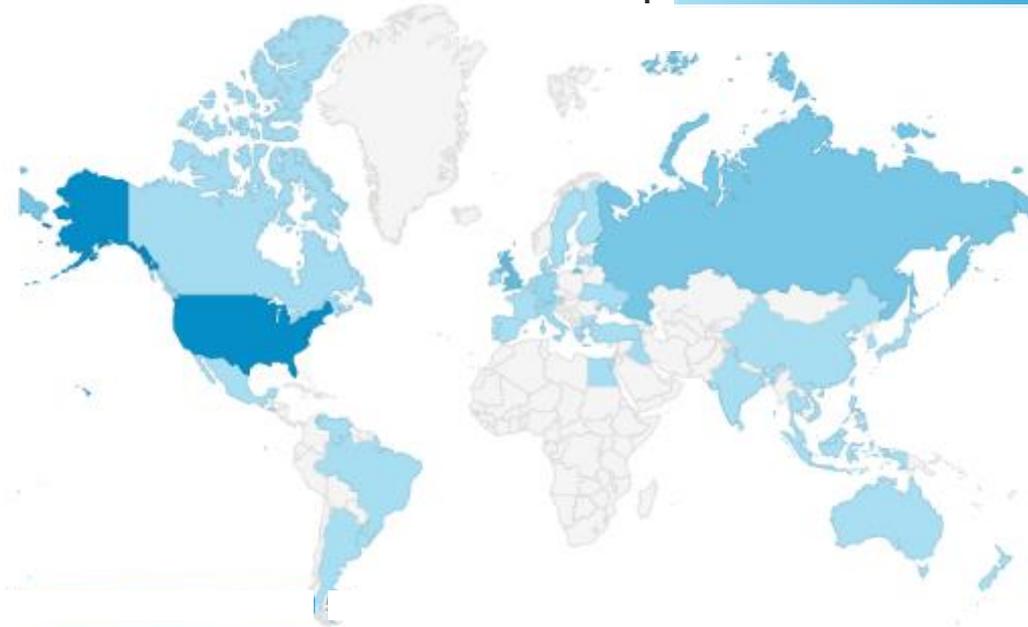


More data is still needed to fully understand quality variability in available biomass resources.

4 – Relevance

- Stakeholders
 - Researchers: Provides the foundation for understanding feedstock variability, quality and blend options
 - Industry: Addresses understanding of feedstock attributes and impacts of logistical processes
 - Policy Makers: Increases understanding of pathways to sustainable energy options through incorporation of grading and quality control
- Users around the world

1  512



5 – Future Work

- Improve project tools
 - Better usability for external users
 - Secure management implementation
- Improve data tools and usability
 - Better tools for variability research (integrated with larger data sets)
 - Enhanced graphical, spatial data visualization
- Develop tools to identify impacts of operations on characteristics
- Improve data completeness and robustness
 - Targeted data requests (e.g., physical data)
 - Research into impacts of certain data points
- Improve visibility and use

Summary

- Overview
 - Develop [central repository](#) for biomass and feedstock samples and data
- Approach
 - [Gather, manage, understand](#), and [share](#) biomass/feedstock samples and data
- Progress and Results
 - Significant [tools](#) developed to manage and understand patterns in the data
- Relevance
 - [Critical resource](#) for understanding aspects of biomass research that are relevant for the industry and BETO
- Future Work
 - Increased [use and visibility](#)
 - Targeted collection of data
- Lessons Learned
 - Critical to meet community needs

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Questions?

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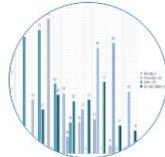
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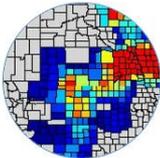
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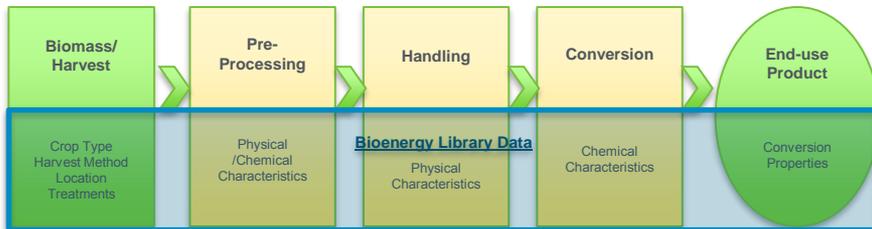
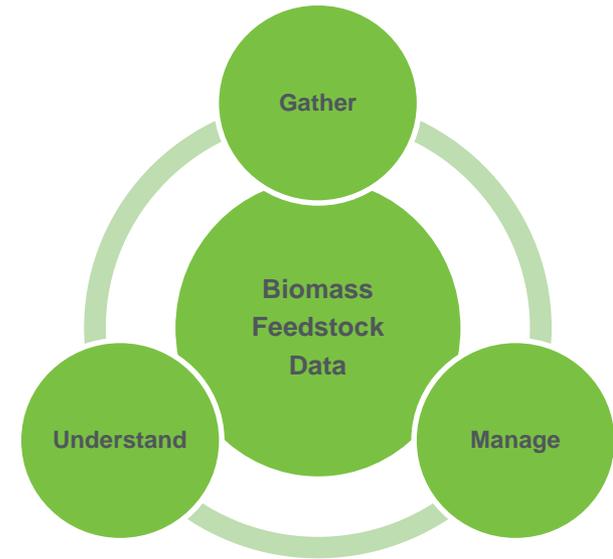
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Additional Slides

Categorization of Data

Sample Classification	Sub Classification
Algae	Algae
Herbaceous	Agricultural Crop
	Agricultural Secondary Waste
	Crop Residues
	Energy Crop
	Perennial Grass
	Other
Woody	Hard Wood
	Soft Wood
	Other
MSW	Forestry Waste
	Garbage Fraction
	Wood Waste
	Other

Parameter Category	Parameter Sub-Category	Description
General	General	Information regarding tracking of the sample. This information is not influential to the quality measurements of the sample.
	Harvest Information	Information specifically about the harvesting of all the sample(s) resulting from a field. This can include harvest dates, general harvesting categorization, and the operations (that includes equipment types).
Site Origin information	Environmental Data	Information about the field or location where the samples were harvested; including soil data, environmental conditions, and field management practices. This type of information can span multiple harvesting combinations.
	Field Management	
	Site Description	
	Soil Data	
Sample Information	Bale Level	Information specific to harvested samples; including bale information, chip information, and core information. This can also include any experimental parameters.
	Core Level	
	Data	
	Experimental	
	Feedstock	