

DOE Bioenergy Technologies Office (BETO)

2023 Project Peer Review

WBS 1.2.2.2 – Bioenergy Feedstock Library

April 3, 2023

Feedstock Technologies Program

Rachel Emerson

Idaho National Laboratory

Project Overview

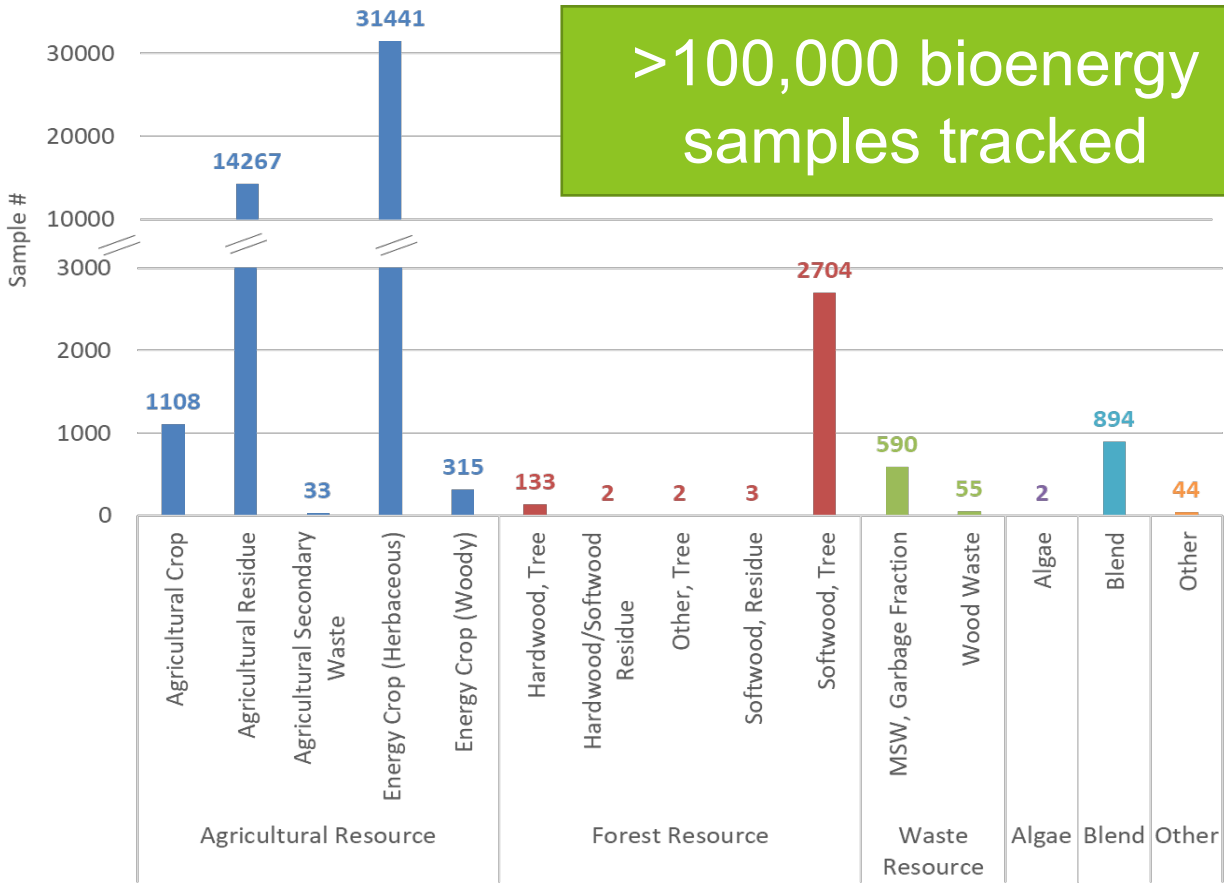
History

- Bioenergy Feedstock Library **established 2008.**
- Used as **sample and data management system.**
- **Web-accessible.**

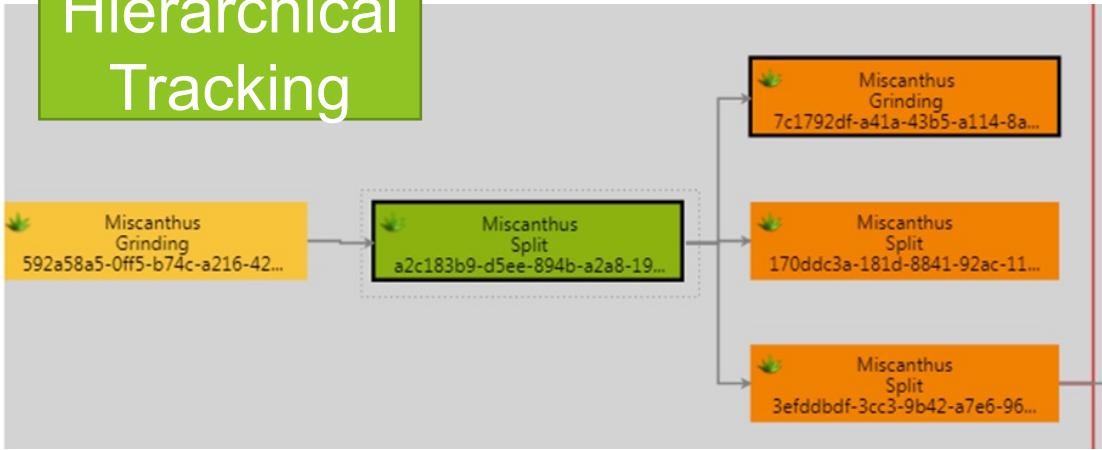
>300 Meta Data Parameters

- Sample information
 - crop type, location, harvest details, historical field information
- Analysis information
 - chemical composition, fuel properties, ash, conversion process characterization
- Operations
 - grinding, pelleting, leaching, storage, conversion processes

>100,000 bioenergy samples tracked



Hierarchical Tracking



<https://bioenergylibrary.inl.gov/Home/Home.aspx>

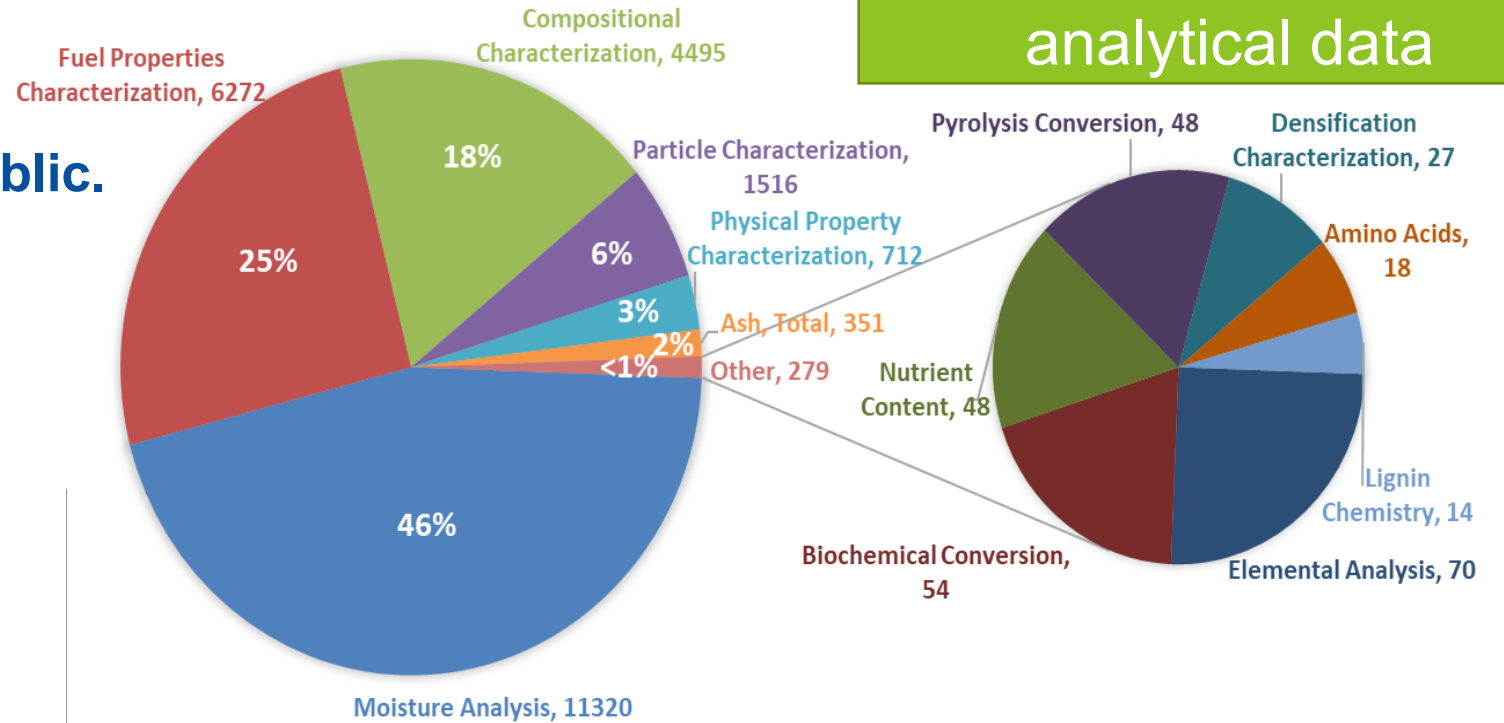
Project Overview

Analytical Data

- Provide analytical data to public.

Datasets with chemical variability

>30,000 samples with analytical data



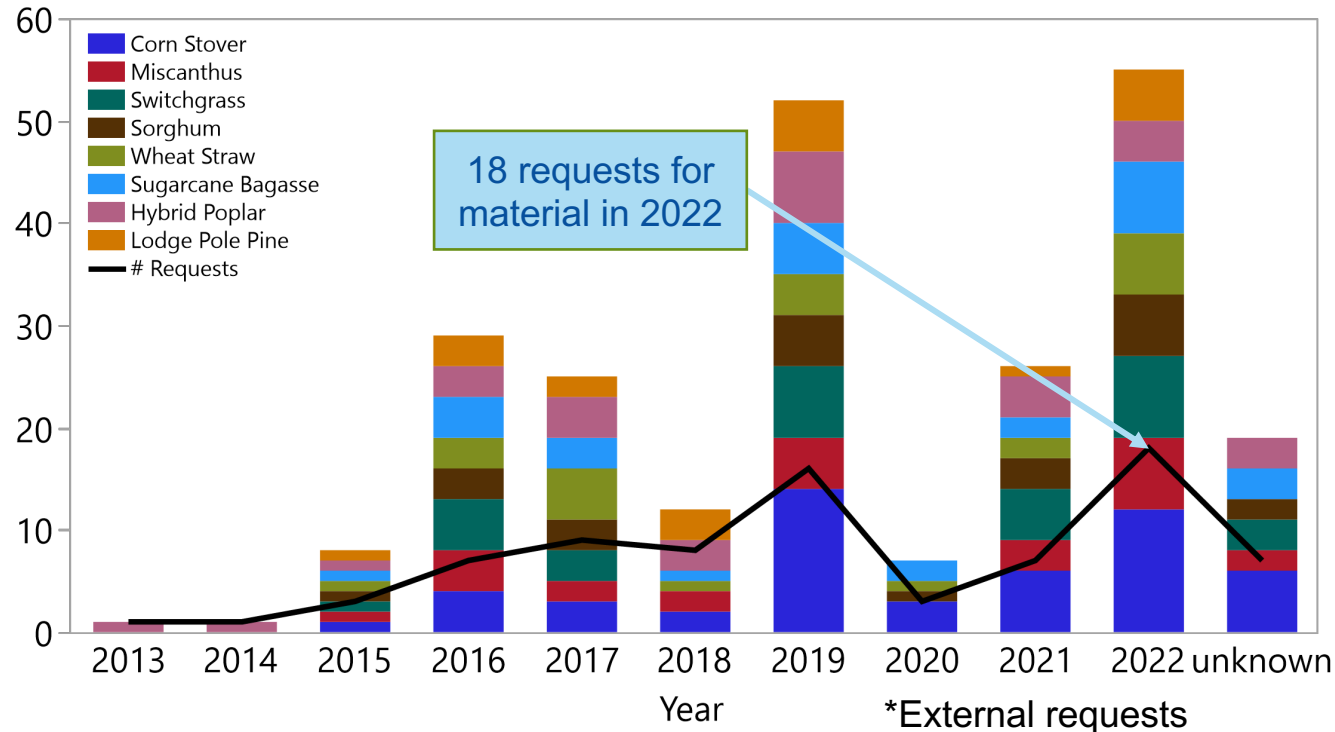
Impact

Analytical data coupled with meta data allows for better understanding of variability.

Project Overview

Physical Samples

- **2015 Reference Materials** represent bulk materials well characterized and split out into sharable samples for bioenergy researchers.
- 200g to 200kg amounts.
- Shared with 100's of researchers within INL and externally.



Switchgrass

REFERENCE MATERIAL

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

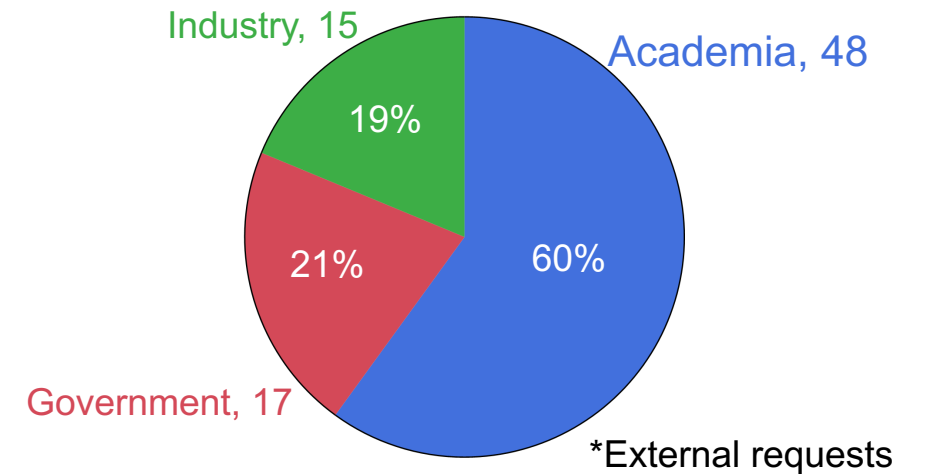
Table 1. Chemical composition^a of Reference Switchgrass (mean of analyses completed 11/2014 & 2/2015)

%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 ^c	%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

^c%Arabinan value includes %mannan, because arabinose and mannose co-elute on the HPLC column



Project Overview

- **Relevance:**

- **Variability in bioenergy feedstock properties** continues to be a **primary challenge** to integrated **biorefineries** achieving continuous operation and meeting yield requirements necessary for commercial scale production of biofuels and chemicals.
- Readily and easily accessible **centralized database** containing large datasets for understanding **bioenergy resource property variability** can help alleviate these challenges.

- **Objectives**

- Provide a centralized, findable and accessible location to **archive physical samples and data** generated from BETO funded projects.
- **Dissemination of data and knowledge** to help “bioenergy researchers and industry understand and overcome challenges posed by the variability of the physical and chemical properties of biomass”.

1 – Approach

Task 1: FOA Sample and Data Management and Archival

Task Objective: Support the archival of samples and data from BETO's FOA projects.

Task 2: Maintenance and Oversight of the BFL Database

Task Objective: Maintain and manage the BFL. Provide physical biomass feedstocks along with associated metadata and analytical data.

Team



Rachel Emerson



Amber Hoover



Marnie Cortez



Ling Ding



Robert Kinoshita



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Noah Berglund

1 – Approach

Task 1: FOA Sample and Data Management and Archival

Task 2: Maintenance and Oversight of the BFL Database

Collaborations

6.3.0.2 Bioenergy Knowledge Discovery Framework (KDF)



FY18 Affordable Sustainable Energy Crops



FY20 Multi Topic –Topic Area 4 (BioRestore)



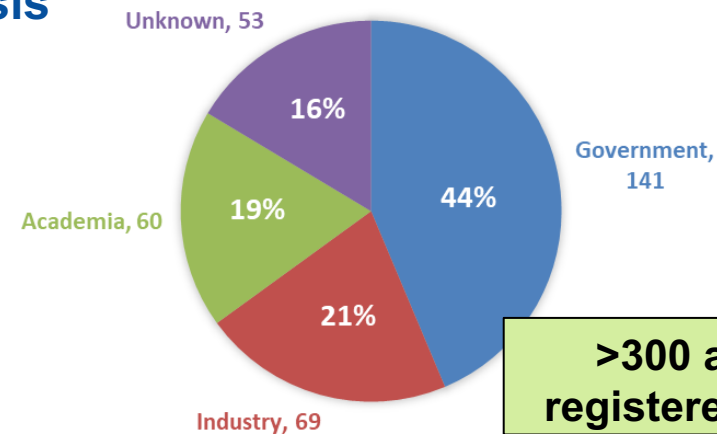
FY21 BETO Feedstocks – Topic Area 1 (MSW)



1.1.1.3 Supply Scenario Analysis



1.1.1.2 Feedstock Supply Chain Analysis



BETO funded INL projects

>300 active registered users

IDAHO NATIONAL LABORATORY

1 – Approach

Metrics for Success (Selected Milestones)

- **FY22Q3 (DEI):** Communicate with **industry/institution focused on bioenergy and social justice/job creation for rural/underserved communities**. Identify relevant BFL data and tools.
- **FY23Q2 (Go/No Go):** Criteria: **Enable archival of 50% of MSW samples** from FOA projects generating MSW.
- **FY24Q4 (EOP):** **Publish a Bioenergy Feedstock Library Annual Summary Report** with the goal of demonstrating a **10% increase** in high priority archived samples and requestable samples, data, and results. **Host a webinar**.

Challenges

- Maintaining high quality data useful data while still providing sample management tools and flexibility.

Risks

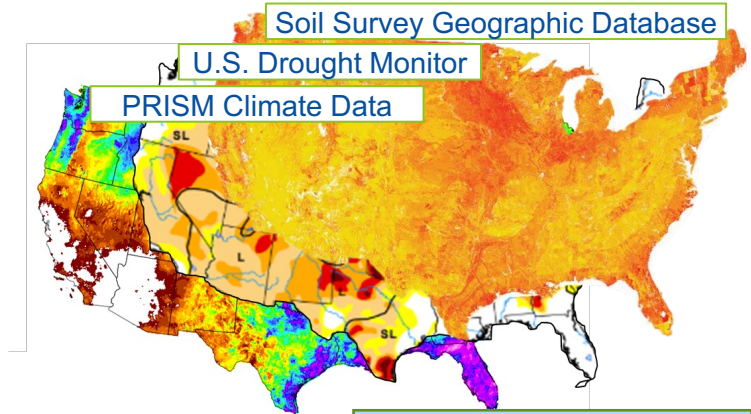
- Maintaining storage costs.
- Limitations on archiving non-stable or hazardous samples.

Mitigations

- Sample management plans detailing physical samples disposal timelines and necessary storage conditions.

2 – Progress and Outcomes

Regional Feedstock Partnership Data Set



Received: 4 October 2022 | Revised: 14 February 2023 | Accepted: 17 February 2023
DOI: 10.1111/gcbb.12942

RESEARCH ARTICLE

Key environmental and production factors for understanding variation in switchgrass chemical attributes

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Abstract
Switchgrass (*Panicum virgatum* bioproducts; however, its inherent longes for uniform conversion to understand the range of switchgrass chemical attributes (switchgrass chemical attributes) influencing chemical composition. The objectives of this fertilizer application rate, year, (2) examine the relationship and (3) develop models to predict. Switchgrass samples from upland cultivars, one location in and six harvest years were used nitrogen, and ash concentrations. Switchgrass chemical attributes, yield, and volatile components were measured. Nitrogen rate was less influential than ash concentration on lignin conditions occurring during the

Regional Feedstock Partnership Biomass Quality Assessment Final Report

October 2021

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Idaho National Laboratory
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INL-EXT-21-43851
Revision 0

Harvest and Nitrogen Effects on Bioenergy Feedstock Quality of Grass-Legume Mixtures on Conservation Reserve Program Grasslands

Cheng-Hsien Lin, Nictor Namoi, Amber Hoover, Rachel Emerson, Marnie Cortez, Ed Wolfram, Courtney Payne, Josh Egenolf, Keith Harmonoy, Robert Kalenbach, Do Kyoung I, D. K. Lee

First published: 02 June 2022 | <https://doi.org/10.1111/gcbb.12980>

Find it @INL

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi:10.1111/gcbb.12980

Abstract
Perennial grass mixtures established on Conservation Reserve Program (CRP) lands can be an important source of feedstock for bioenergy production. This study aimed to evaluate management practices for optimizing the quality of bioenergy feedstock and stand persistence of grass-legume mixtures under diverse environments. A five-year field study (2008-2012) was conducted to assess the effects of two harvest timings (at anthesis vs. after complete senescence) and three nitrogen (N) rates (0, 56, 112 kg N ha⁻¹) on biomass chemical compositions (i.e., cell wall components, ash, volatiles, total carbon, and N contents) and the feedstock energy potential, examined by the theoretical ethanol yield (TEY) and the total TEY (i.e., the product of biomass yield and TEY, L ha⁻¹), of cool-season mixtures in Georgia and Missouri and a warm-season mixture in Kansas. The canonical correlation analysis (CCA) was used to investigate the effect of vegetative species transitions on feedstock quality. Although environmental variations (mainly precipitation) greatly influenced the management effect on chemical compositions, the delayed harvest after senescence generally improved feedstock quality. In particular, the overall cell wall concentrations and TEY of the warm-season mixtures increased by approximately 7%. Additional N supplies improved the total TEY of both mixtures by ~1.6–4.2 L ha⁻¹ per 1.0 kg N ha⁻¹ input but likely lowered the feedstock quality, particularly for the cool-season mixture. The cell wall concentrations of cool-season mixture reduced by approximately 3–6%. The CCA results indicated that the increased legume compositions (under low N input) likely enhanced lignin but reduced ash concentrations. This field research demonstrated that with proper management, grass-legume mixtures on CRP lands can provide high-quality feedstock for bioenergy productions.

<https://doi.org/10.1111/gcbb.12942>

<https://doi.org/10.2172/1862678>

<https://doi.org/10.1111/gcbb.12980>

U.S. DEPARTMENT OF **ENERGY** Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Drought and Data: Planning for Year-to-Year Variability as Extremes Widen
DOE Office of Energy Efficiency and Renewable Energy sent this bulletin at 01/24/2023 04:26 PM EST

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Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Bioenergy Technologies Office

January 24, 2023

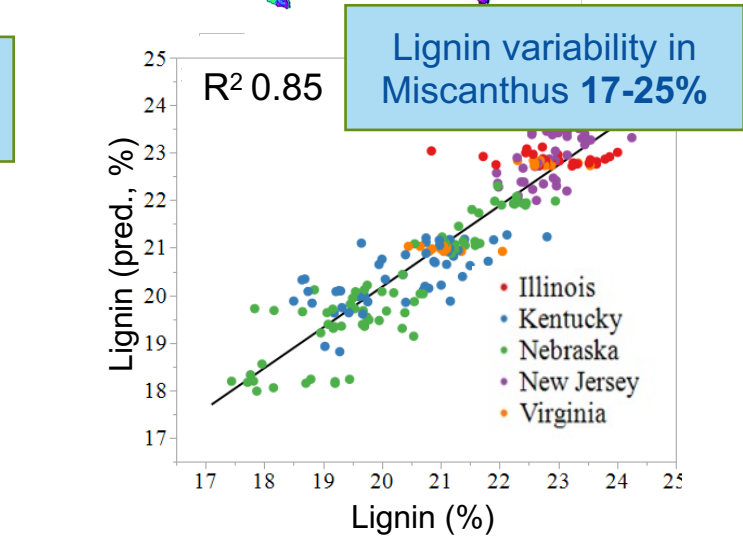
Drought and Data: Planning for Year-to-Year Variability as Extremes Widen

Highlighted in EERE article

<https://content.govdelivery.com/accounts/USEERE/bulletins/344ab17>

Highlights:

- Evaluation of the impacts of agronomic designs, genetics, and environmental conditions on chemical properties.
 - Drought impacts.
- Spatial and temporal environmental quality prediction maps.



Impact


- RFP is a high impact dataset and sample set representing spatially and temporally explained chemical variability.
- >130 publications (30 focused on chemical variability).

2 – Progress and Outcomes

Sample and Data Management Plans

Each INL project (and FOA projects) will develop a **Sample and Data Management Plan**

- How samples will be **archived, analyzed, and shared.**
- **How long** samples will be retained (under the originating project).
- How **data** will be **managed and shared.**
- **Dataset disclaimers** and pertinent details.



Bioenergy Feedstock Library Sample and Data Management Plan

Project
ASEC FOA—Next Generation Miscanthus: Hybrid Performance Evaluation and Enhanced, Sustainable Feedstock Production and Supply in the Southeast U.S. for Biofuels and Bioproducts

Project Timeline
10/01/2018 – 12/31/2022

Project PIs/POCs
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INL Contacts
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Purpose
This Sample and Data Management Plan is intended to set expectations for the Bioenergy Program regarding sample storage, sharing, and disposition to allow for enhancing the value of samples through sharing, functional and safe workspaces, and discarding of samples that have lost value as a physical sample. In addition, this plan also details requirements for sharing of data associated with samples, which can occur before or after physical samples are discarded.

Sample Storage
These samples will be stored indoors at room temperature in a stable condition (e.g., <10% moisture) for the duration of the project and archival period.

Sample Storage Duration
These samples will be archived for 10 years from the end of the project or 5 years from the date of public release of samples, whichever is shorter.

Impact

Standardized method for establishing when **samples and data can be publicly shared.**

2 – Progress and Outcomes

FOA Sample Archival

Impact
Samples and data archived from these projects will be **made publicly available.**

												Archived Samples
		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
FY18 Affordable and Sustainable Energy Crops	University of Illinois			★		★						Switchgrass 478
	North Carolina State University			★		★						Miscanthus 180
	Texas A&M University			★		★						Sorghum & Energy cane 619
FY20 BETO Multi-Topic <i>Topic Area 4—Bio-Restore: Biomass to Restore Natural Resources</i>	Mississippi State University					★						Hybrid Poplar & Eastern Cottonwood 72
	University of Florida											
	University of Nebraska Lincoln											TBD
FY21 BETO Feedstocks <i>Topic Area 1—MSW Feedstock Technologies</i>	University of Maryland					★						
	North Carolina State University					★						
	Lehigh University						★					
	Cascadia											TBD
	AMP Robotics											TBD

- ★ Sample Archival Protocol draft
- ★ Sample Archival Protocol established
- ★ Sample and Data Management Plan established

Impact

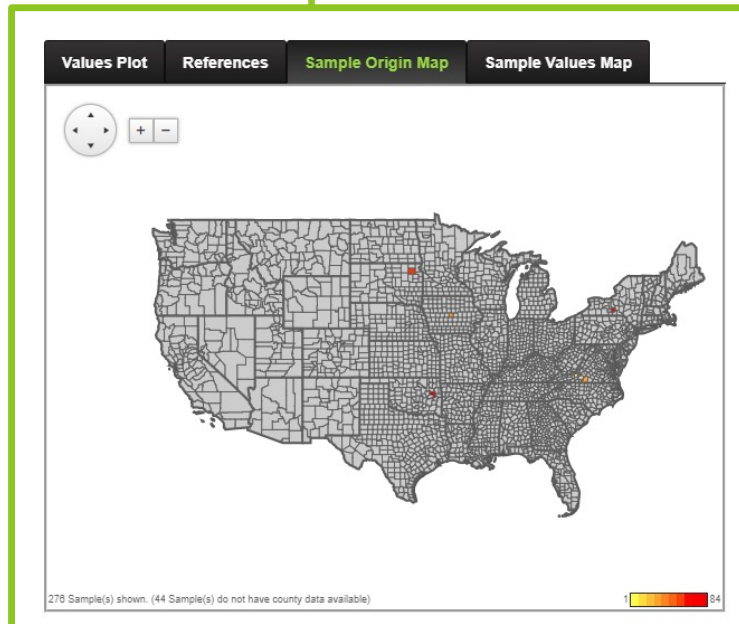
Demonstrates how BFL can support bioenergy and social justice/job creation in rural/underserved communities.

2 – Progress and Outcomes

Diversity, Equity, and Inclusion

- Met with **Bioeconomy Development Opportunity (BDO) Zone** team at **Ecostrat Inc.**
- BDO Zones intended to **create bioenergy job creation** in rural and underserved communities.
- BDO Zone Rating Framework requires **understanding spatial and temporal variability in feedstock quality** for a given location.

Attribute Graphs



<https://bioenergylibrary.inl.gov/Research/NewGraphAnalyses.aspx>

Request Biomass

To request biomass for research purposes from the Biomass Resource Library, please complete the following form:

Full Name:

E-mail Address:

Phone Number:

Shipping Address:

Institutional Affiliation:

Requested Material:	Crop Type	Amount
Blend:	<input type="text"/>	<input type="text"/>
Corn Stover:	<input type="text"/>	<input type="text"/>
Hybrid Poplar:	<input type="text"/>	<input type="text"/>
Lodge Pole Pine:	<input type="text"/>	<input type="text"/>
Miscanthus:	<input type="text"/>	<input type="text"/>
Sorghum:	<input type="text"/>	<input type="text"/>
Sugarcane Bagasse:	<input type="text"/>	<input type="text"/>
Switchgrass:	<input type="text"/>	<input type="text"/>
Wheat Straw:	<input type="text"/>	<input type="text"/>

Shipping Account Number (FedEx/UPS):

Comments, special considerations, and intended use:

Verify that you are a real SKQX2

<https://bioenergylibrary.inl.gov/Sample/RequestBiomass.aspx>

Data Sets

Data Sets

Access or add Bioenergy Feedstock Library Data Sets here.

Suggested Citation: Author(s). "Dataset Title." Dataset ID, U.S. Department of Energy, Idaho National Laboratory, Bioenergy Feedstock Library, dataset URL. e.g. (John Doe. "Example Data Set Name." 1001, U.S. Department of Energy, Idaho National Laboratory, Bioenergy Feedstock Library. <https://bioenergylibrary.inl.gov/data/dataset.aspx?id=Data Set ID>)

If a citation does not exist in the 'Available Citations' for associating with a give Data Set, the citation can be added through the [Citation Management](#) page.

Data Set Id	Data Set Name	Description	Author/Institution	Public?	Citation Count	File Count	Sample Count	Writer Count	Whitable?
1002	Regional Feedstock Partnership Switchgrass Dataset	Chemical attribute data available for the Regional Feedstock Partnership switchgrass field study samples.	Regional Feedstock Partnership and Idaho National Laboratory	True	1	2	373	3	False
1006	Image analysis for rapid assessment and quality-based sorting of corn stover dataset	Experimental data supporting publication focused on developing a rapid assessment for quality-based sorting of corn stover using image.	Ding, L., Hoover, A.N., Emerson, R.M., Lin, K., Gruber, J.N., Donohoe, B.S., Klinger, J.L., Colby, R.D., Thomas, B.J., Smith, W.A., and Ray, A.E.	True	1	1	643	3	False

Page size: 3 2 items in 1 pages

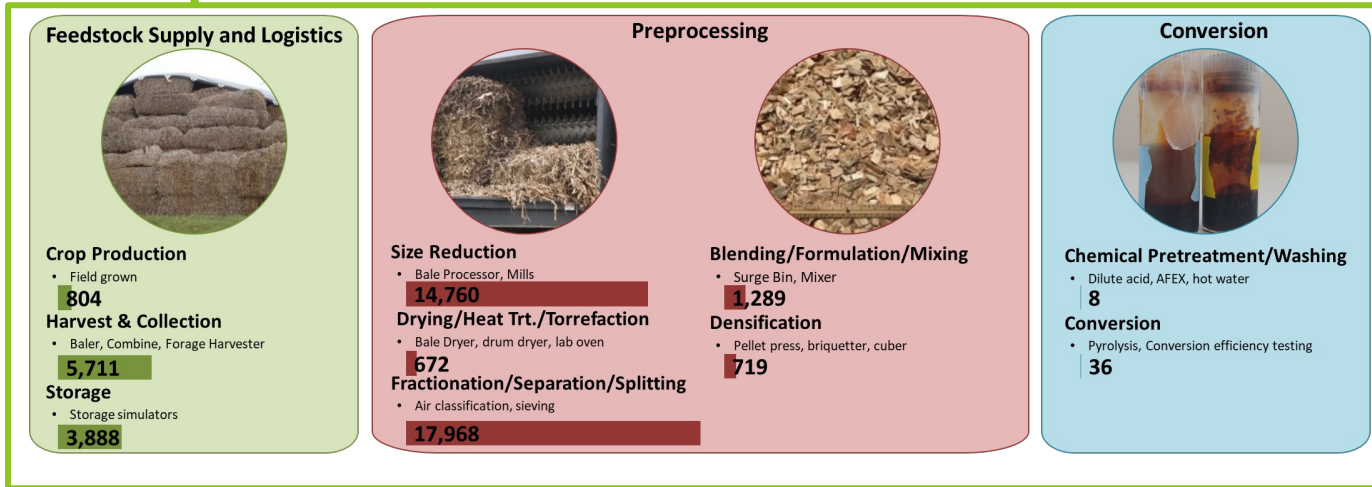
<https://bioenergylibrary.inl.gov/Data/Dataset.aspx>

2 – Progress and Outcomes

Annual Summary Report

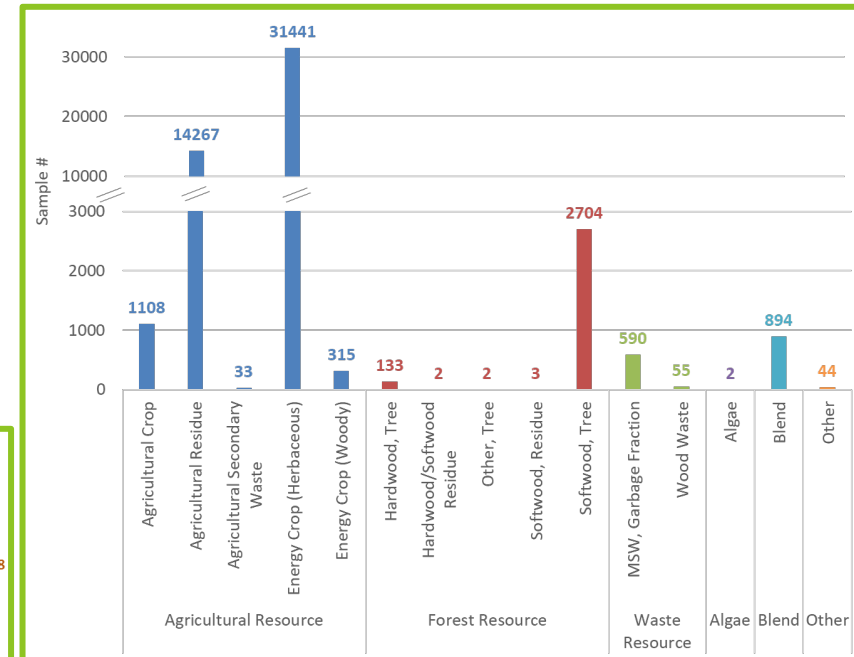
Objective: Highlight data, information, and samples publicly available.

Unit Operations

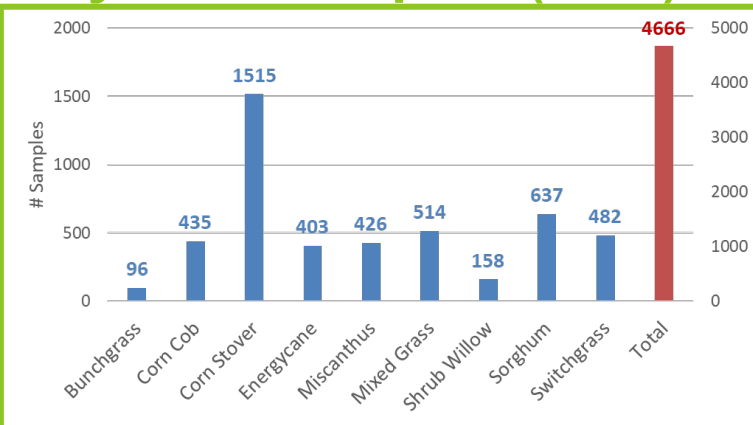


Feedstock Resources

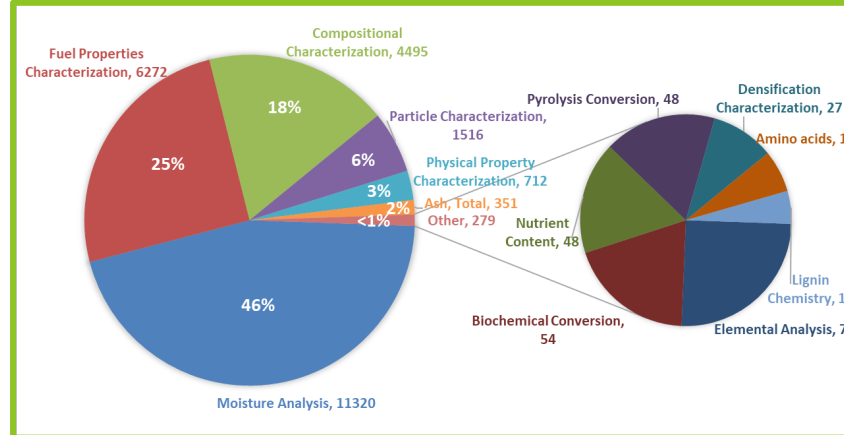
Cultivars/varieties



Physical Samples (RFP)



Analytical Data



Impact
Dissemination strategy to provide citable documentation on BFL progress for publicly available information.

3 – Impact

Biomass Variability

- Provides samples and data for better understanding variability in bioenergy feedstocks

Dissemination:

- **Publicly available website**
 - **Provide training and/or technical assistance** for obtaining datasets and information **weekly**
- Provide **physical samples**
 - **Reference materials** shipped out **monthly** to research groups
- **Conferences**
 - Fact sheet that is handed out booths (<https://bioenergy.inl.gov/Fact%20Sheet/Biomass%20Feedstock%20Library.pdf>)
- **Publications (2)** and **Technical Reports (2)**
- **Webinars** (planned for FY23 and FY24)

Supports BETO Goals

- **Decarbonizing Energy-Intensive Industries** and **Transportation** pillars based on the **variability data** and samples provided through the **large variety of bioenergy feedstocks**.
- Bioenergy Feedstock Library facilitates **better understanding of variability in chemical and physical properties for bioenergy feedstocks**, including but not limited to biomass, supporting:
 - Both short term goals of >50% GHG emissions by 2030 through longer term goals of CO₂ utilization for chemicals by 2050.
 - Reduction in CO₂ emissions and commercialization of Sustainable Aviation Fuel.

Summary

- **Objectives:**

- Provide a centralized, findable and accessible location to archive physical samples and data generated from BETO funded projects.
- Dissemination of data and knowledge to help “bioenergy researchers and industry understand and overcome challenges posed by the variability of the physical and chemical properties of biomass”.

- **Progress:**

- **Archival of samples and data** from BETO’s 11 current FOA projects to develop **high impact sample and data sets**.
- **Maintain and manage** the BFL database.
- **Provide** relevant physical biomass **feedstocks, metadata, and analytical data** to stakeholders and research groups.

- **Relevance:**

- The Bioenergy Feedstock Library (BFL) represents one of the **largest publicly accessible databases** for feedstock variability that is **actively maintained**. The data and samples requested weekly from the BFL team highlight the **need for this resource in our bioenergy research community**.

Quad Chart Overview

Timeline

- 10/1/2021
- 9/30/2024

	FY22 Costed	Total Award
DOE Funding	\$458,792	Total: \$750,000

TRL at Project Start: N/A (Modality #4—Testing, Data Collection and Data Dissemination)

TRL at Project End: N/A (Modality #4—Testing, Data Collection and Data Dissemination)

Project Partners*

- BETO FOA Projects (12 Projects)

Funding Mechanism

AOP

Project Goal

Through this project our objective is to provide a centralized, easily findable and accessible location to archive physical samples and data generated from across the various BETO funded projects with the specific goal of data and knowledge dissemination helping “researchers and industry understand and overcome challenges posed by the variability of the physical and chemical properties of biomass while providing all stakeholders with accessible data about the physical and chemical properties of a wide variety of feedstock materials.”

End of Project Milestone

FY24Q4 (EOP) - Publish a Bioenergy Feedstock Library Annual Summary Report with the goal of demonstrating a 10% increase in high priority archived samples and a 10% increase or 2 projects in requestable BFL physical samples, data, and results. Host a webinar following the technical publication for further result dissemination.



Additional Slides

Responses to Previous Reviewers' Comments

This project was a “New Start” Project in FY21. The responses below were comments regarding the BFL specifically from a previous project “WBS 1.2.2.2 - Standardized Risk Assessment and Critical Property Analytics” which funded maintenance and continuation of the BFL website.

Reviewers Comment FY21:

- “I am a strong supporter of the **Bioenergy Feedstock Library**; it is a **valuable resource**. I am going to use the rest of my space here to advocate for a companion library for equipment cost. I am thinking specifically about the mobile machines used to harvest and deliver biomass. There is a wide variety of this equipment from a mower-conditioner cutting switchgrass to a chip van delivering wood chips. My idea is for a central repository for operating cost data (\$/h) for all these machines, and a common procedure for calculating these costs.”

Response to Reviewer Comment FY21:

- “The reviewer brings up an important aspect of an equipment logistics cost type database. Though this is likely out of scope for this specific project, it is an important programmatic objective that INL is well poised to contribute potentially through our INL’s Feedstock Technology platform projects. We appreciate the reviewer’s thoughts on this higher-level goal.”

Publications, Patents, Presentations, Awards, and Commercialization

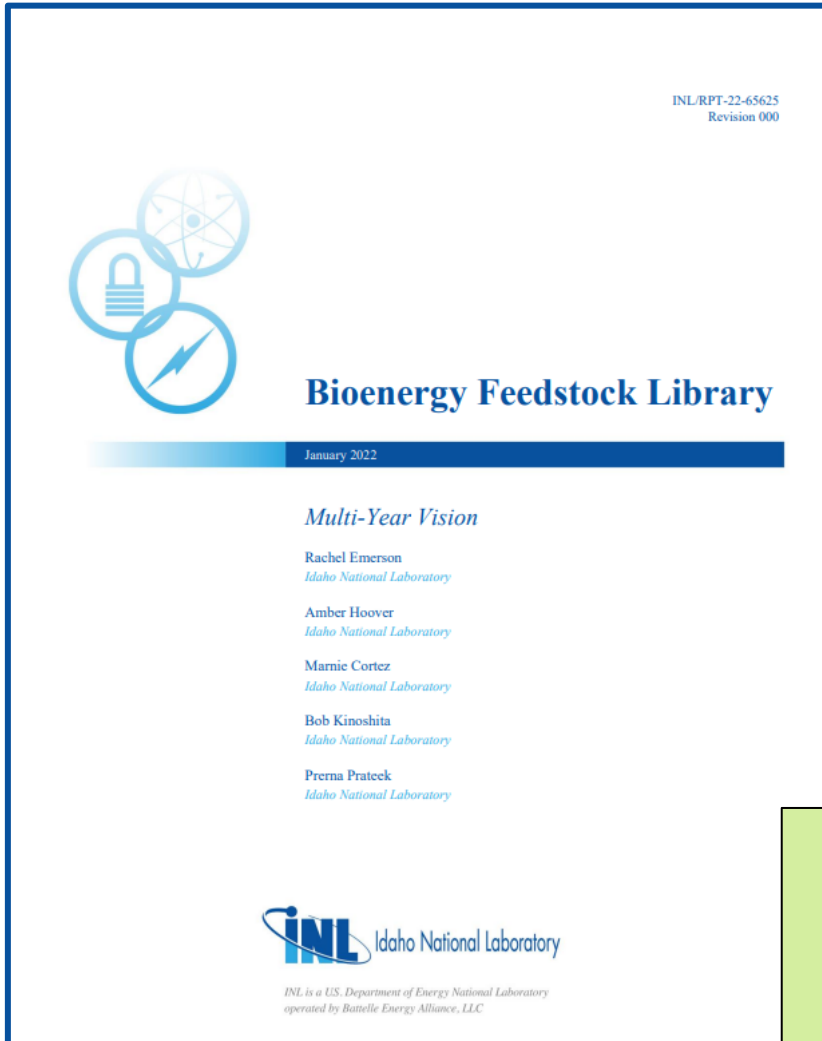
Publications

- Emerson, Rachel M, Cortez, Marnie M, Kinoshita, Robert A, & Hoover, Amber N. *Bioenergy Feedstock Library Annual Summary Report - 2022*. United States. <https://doi.org/10.2172/1894328>
- Hoover, A. N., Emerson, R., Cortez, M., Owens, V., Wolfrum, E., Payne, C., Fike, J., Crawford, J., Crawford, R., Farris, R., Hansen, J., Heaton, E. A., Kumar, S., Mayton, H., & Wilson, D. M. (2022). Key environmental and production factors for understanding variation in switchgrass chemical attributes. *GCB Bioenergy*, 14, 776–792. <https://doi.org/10.1111/gcbb.12942>
- Emerson, Rachel M, Hoover, Amber N, Cortez, Marnie M, Rials, Timothy, Owens, Vance, Voigt, Thomas, Lee, DoKyoung, Fike, John, Baldwin, Brian, Rooney, William L., & Volk, Timothy A.. *Regional Feedstock Partnership Biomass Quality Assessment Final Report*. United States. <https://doi.org/10.2172/1862678>
- Lin, C.-H., Namoi, N., Hoover, A., Emerson, R., Cortez, M., Wolfrum, E., Payne, C., Egenolf, J., Harmony, K., Kallenbach, R. and Lee, D.K. (2022), Harvest and Nitrogen Effects on Bioenergy Feedstock Quality of Grass-Legume Mixtures on Conservation Reserve Program Grasslands. *GCB Bioenergy*. 00, 1–20. <https://doi.org/10.1111/gcbb.12980>

3 – Progress and Outcomes

Bioenergy Feedstock Library Multi-Year Vision Plan

- Long-term (10 year) vision for the BFL
- Outlines how the BFL will **increase the number of datasets and physical samples publicly available.**
- Identify improvements that can be made to the current **structure, processes, and policies** to better share data, samples, and information.
- **Project Organization**
- **Sample and Data Management Plans**
- **Outreach for Publicly Available Samples**



INL/RPT-22-65625
Revision 000

Bioenergy Feedstock Library

January 2022

Multi-Year Vision

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Prerna Prateek
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INL Idaho National Laboratory

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Impact
Roadmap for reaching
goals of better data and
knowledge dissemination