

GROWING ENERGY: COMPARING BIOENERGY CROP YIELDS



Overview: Can perennial biomass crops compete with king corn? In this GLBRC *Data Dive*, students analyze and interpret data on the biomass production of different bioenergy crops grown on Great Lakes Bioenergy Research Center (GLBRC) experimental farms in Wisconsin and Michigan. Students read a brief summary of the GLBRC research questions and experimental design. They then are given the task of interpreting real GLBRC biomass data to answer the research questions about how perennial biomass crops, such as switchgrass and prairies, compare to corn.

LEVELS

High School (9-12)

SUBJECTS

Environmental Science, Biology, Agriculture, Earth Science

OBJECTIVES

- Identify the scientific questions and variables in GLBRC bioenergy crop farming experiment
- Interpret biomass units from the experiment (megagrams per hectare) and compare them to familiar mass and area units
- Analyze and interpret data on crop biomass production
- Propose an answer to the scientific question and support it with evidence from the data

MATERIALS

Growing Energy Data Dive Package

ACTIVITY TIME

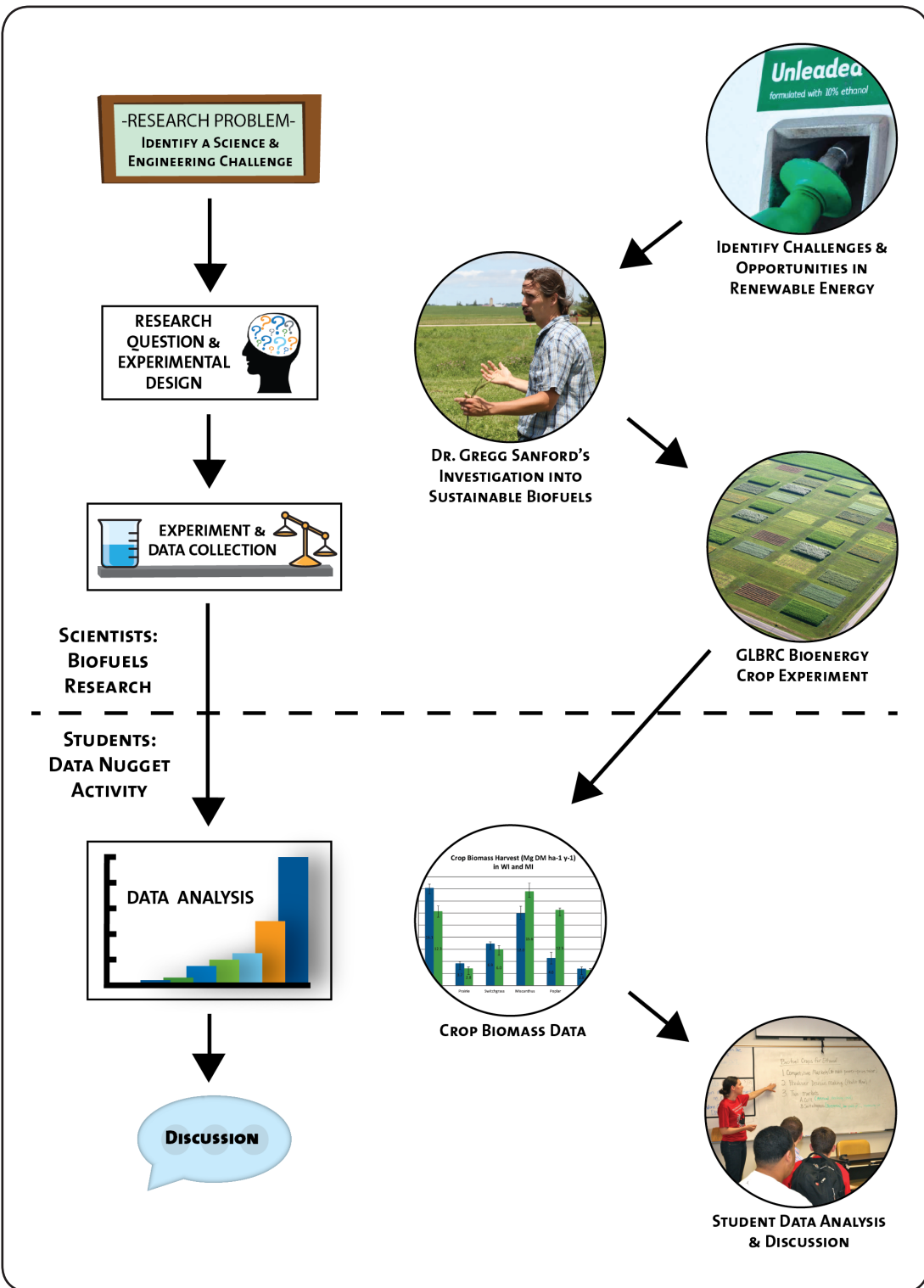
One or two 50-minute class periods

STANDARDS

Next Generation Science Standards (2013)

- Scientific Practices: analyzing and interpreting data; engaging in argument from evidence
- Disciplinary Core Ideas: ecosystems; earth and human activity
- Crosscutting Concepts: patterns; scale, proportion, and quantity; energy and matter
- Performance Expectations: See page 3 for details

NGSS Lead States. 2013. Next Generation Science Standards: For States by States. Washington DC: The National Academies Press



Growing Energy: Comparing Bioenergy Crop Yields

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Learning Outcomes: Students will...

- Identify the scientific questions and variables in GLBRC bioenergy crop farming experiment
- Interpret biomass units from the experiment (megagrams per hectare) and compare them to familiar mass and area units
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This lesson assumes prior familiarity with the scientific method, hypothesis testing, graphing (if students are asked to create their own), graph interpretation, and basic statistics. For helpful resources on covering these concepts see:

<http://datanuggets.org/concepts-to-cover-before-introducing-nuggets/>

Standards

Next Generation Science Standards (2013)

Performance Expectations

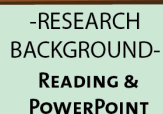
High School:

- **HS-LS2-2.** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- **HS-ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p>Analyzing and interpreting data</p> <p>Engaging in argument from evidence</p>	<p>LS2: Ecosystems: Interactions, energy, and dynamics</p> <p>ESS3: Earth and human activity</p>	<p>Patterns</p> <p>Scale, proportion, and quantity</p> <p>Energy and matter: Flows, cycles, and conservation</p>

Activity Sequence:

Research Background:



-RESEARCH
BACKGROUND-
READING &
POWERPOINT

1. OPTIONAL: Have students read and discuss a short [Science of Farming](#) research story for a more detailed background to the investigation.
2. Read and discuss the Research Background as a class. Have students identify science question driving the experiment.
3. Use accompanying PowerPoint slides to review key terms (biofuels, biomass, annual, perennial), review experimental design and to introduce the bioenergy crops with pictures.
4. Hand out worksheets with the appropriate graph level for your students as described below. Start by handing out only the Research Background section and Part 1 of the data analysis.
 - a. Type A: data displayed on graph; axis labels and scale provided
 - b. Type B: students graph data; axis labels and scale provided
 - c. Type C: students graph data; axis labels and scale not provided
5. Review and discuss data table in Part 1. Have students identify independent and dependent variables.
6. Interpret the biomass measurement unit $\text{Mg DM ha}^{-1} \text{ yr}^{-1}$. If time permits, have students complete the supplementary “Interpreting units” worksheet. Discuss and review answers using the accompanying PowerPoint presentation to help students visualize the scale of the units.

Data Analysis & Interpretation:

7. Part 1: Have students complete Part 1 of the data analysis and interpretation worksheet comparing average biomass across sites.
8. Share graphs and discuss answers as a class. In constructing a scientific argument, it is important for students to pinpoint specific numbers, trends and difference in the data to support their statements. Discussing next research steps should lead into questions about differences in results between the MI and WI sites (worksheet Part 2).
9. Part 2: Give students and have them complete Part 2 of the data analysis and interpretation worksheet comparing average biomass between sites.
10. Discuss answers and compare answers between Part 1 and Part 2. Guide students through comparing how the answers can vary depending on how data is aggregated and discuss benefits of analyzing at difference scales.
11. Sample grading rubric. See the [sample grading rubric](#) at DataNuggets.org.



DISCUSSION

Extensions, Variations, and Related Lessons:

1. As a warm-up or follow-up activity play the [Fields of Fuel video game](#) or [Bioenergy Farm board game](#) so students can grapple with the economic-environmental tradeoffs associated with farming in a realistic multiplayer simulation.
2. Before this activity, have students read and discuss the short [Science of Farming](#) research story for an in-depth look at the scientists working on this experiment.
3. Use the [Root Depth Model](#) activity to help create a visual representation of the differing root depths in biofuel crops and prairie plants as well as promote discussion about plants' ability to sequester carbon and contribute to soil carbon.
4. Have students conduct their own investigations using the [Field Investigations: Biomass Yield and Root Growth in Crops](#) to strengthen their understanding of the ability of plants to sequester carbon above and below ground.
5. Advanced students can conduct their own data analysis of this experiment or other related research questions using the spreadsheet included in "Supplemental Materials."

Additional Resources:

- The **GLBRC Education and Outreach site** has a collection of many other high-quality instructional materials to explore dimensions of producing and using biofuels appropriate for a range of K-12 STEM subjects and content areas. See: <https://www.glbrc.org/education/classroom-materials>.
- The **MSU Data Nuggets site** has many helpful resources for teachers, including materials for introducing students to the scientific method, scientific argumentation and basic statistics. See: <http://datanuggets.org/>

- **Reference Article:** See how the researchers analyzed, explained and discussed this data in the following publication:

*Gregg R. Sanford, Lawrence G. Oates, Poonam Jasrotia,
Kurt D. Thelen, G. Philip Robertson, Randall D. Jackson,
Comparative productivity of alternative cellulosic
bioenergy cropping systems in the North Central USA,
Agriculture, Ecosystems & Environment, Volume 216, 15
January 2016, Pages 344-355, ISSN 0167-8809, [http://
dx.doi.org/10.1016/j.agee.2015.10.018](http://dx.doi.org/10.1016/j.agee.2015.10.018).*



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