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# K-12 Partnership Lesson Plan

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# BEST plots ~ Using Student-Collected Data in the Classroom

# *Making predictions, drawing conclusions, and supporting claims with evidence*

## Overview

In this lesson, we use questions generated for and data collected from the BEST (BioEnergy SusTainability) plots to have students make predictions, draw graphs, interpret data patterns, and support claims with evidence. Students play a fun and engaging game that helps them think about the biology involved in how plants grow or how invertebrates find food in their environment. The outcomes of the game help students make predictions. We also have four worksheets available at different levels of difficulty that get students looking at real data, making graphs, and drawing conclusions based on evidence. The lesson focuses on parts of the overarching scientific question for the BEST plots: “Can we grow our fuel and save our flowers and butterflies, too?”

The game in this lesson plan and each of the four activities can stand alone, or be done together as a unit.

We think about the following questions and provide activities for each of them:

(1) How do the kinds of plants we planted (switchgrass and prairie) affect how much plants grow (measured as biomass)?

(2) How does soil moisture affects biomass?

(3) How does biomass affect the diversity of invertebrates?

(4) How does the diversity of plants affect the diversity of invertebrates?

**Objectives**

At the conclusion of the lesson, students will be able to:

* Make predictions about the scientific questions above
* Describe patterns in data
* Make graphs
* Summarize data from graphs
* Interpret patterns in data
* Use evidence to support their claims/conclusions

**Length of Lesson**

Two 45- to 60-min periods or more if all materials are used. Each section can stand alone.

* One for discussion of scientific question and game to generate predictions related to biodiversity
* 30-60min for a single activity
* Each additional activity you choose to cover may take about 20-60min, depending on how familiar your students are with graphing and interpreting data

**Grade Levels**

4-12 (use materials labeled “L1” for elementary school/lower middle school)

**Standards covered (NGSS)**

Disciplinary Core Ideas:

* **MS-LS2-1**: analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem
* **MS**-**LS2-4**: construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations
* **MS-LS2-5**: evaluate competing design solutions for maintaining biodiversity and ecosystem services
* **MS-LS1-5**: construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms

Cross Cutting Concepts:

* Patterns
* Scale, proportion, and quantity
* Energy and matter in systems

Science and Engineering Practices

* Asking questions and defining problems
* Analyzing and interpreting data
* Using mathematics and computational thinking
* Engaging in argument from evidence

***Previous Michigan Standards Met:***

* **S.IP.00.16**: construct simple charts from data and observations
* **S.IP.05.16**: identify patterns in data
* **S.IA.00.13, 03.13, 05.13**:communicate and present findings of observations and investigations
* **S.IA.03.11, 05.11**: summarize information from charts and graphs to answer scientific questions
* **S.RS.00.11**: demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities
* **S.RS.01.12**: recognize that science investigations are done more than one time
* **S.RS.02.15**: use evidence when communicating scientific ideas
* **L.OL.00.11**: identify that living things have basic needs
* **E.SE.00.12**: describe how Earth materials (including water) contribute to the growth of plant and animal life
* **L.OL.02.14**: identify the needs of plants
* **E.ES.03.41**: identify natural resources (metals, fuels, fresh water, fertile soil, and forests)
* **E.ES.03.42**: classify renewable (fresh water, fertile soil, forests) and non-renewable (recyle, reuse, reduce, renewal)
* **E.SE.03.32**: describe how materials taken from the Earth can be used as fuels for heating and transportation
* **L.EC.06.21**: describe common patterns of relationships between and among populations (competition, parasitism, symbiosis, predator/prey)
* **B1.1B**: evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions
* **B1.1E**: describe a reason for a given conclusion using evidence from an investigation
* **B1.1g**: use empirical evidence to explain and critique the reasoning used to draw a scientific conclusion or explanation
* **L3.p2A**: describe common relationships among organisms and provide examples of producer/consumer, predator/prey, or parasite/host relationship
* **L3.p3D**:predict how changes in one population might affect other populations based upon their relationships in a food web
* **B3**.**4d**: describe the greenhouse effect and list possible causes
* **B3.4e**: list the possible causes and consequences of global warming

**Materials**

* Powerpoint presentation to introduce BEST plots, game, and four activities (materials found on “BEST plots: using real data…” lesson page on the KBS GK-12 website)
* Game materials
  + Mat (we used textured car mats, you can use anything that keeps materials from rolling everywhere, like carpet pieces)
  + Tools (we used spoons, forks, toothpicks, pipe cleaner pieces, and magnets; you can use a variety of tools that are better or worse at picking up the nutrients below)
  + Nutrients (we used two sizes of beads, foam pieces, paperclips, and small crumpled pieces of paper; you can use a variety of objects with different shapes and sizes)
  + Activities (one available at elementary/early middle school skill level, four available at advanced middle school/high school level)

**Background**

Students have the opportunity to make predictions, interpret data, and make conclusions about the long-term school yard research plots (BEST plots). Some classes have even had the opportunity to collect this data, which makes this a great continuation of their experience with the scientific method. Even students that don’t have access to research plots or haven’t collected data will benefit from practicing parts of the scientific method. Sometimes much of class time is spent collecting data, leaving little time in the classroom to interpret data and make conclusions. In this lesson, the data is already available, so students can focus on describing and interpreting patterns. Additionally, the activities put emphasis on supporting conclusions with evidence from graphs and data tables.

Additional background relevant to each question is provided on the student worksheets found on the “BEST plots: using real data...” lesson page on the KBS GK-12 website.

### Activities of the session

1. **Introduction to BEST plots (use PowerPoint Presentation)**
   1. Briefly explain using plants as fuel as an alternative to fossil fuels like coal or gas.
      1. Burning fuel to run our cars or heat our homes releases carbon dioxide into the atmosphere, and carbon dioxide is one of the primary greenhouse gases contributing to climate change.
      2. Using plants as fuel can help reduce human impact on climate change because plants take up carbon dioxide as they grow. Plants do release carbon dioxide when we burn them to make fuel, just fossil fuels release carbon dioxide when burned. However, the fact that plants also take up carbon dioxide when they grow (i.e., photosynthesis) makes using plants as fuel a cycle of taking up and releasing carbon dioxide, whereas using fossil fuels only releases carbon dioxide.
   2. Introduce how the BEST plots are set up and what comparisons we’re making.
   3. Introduce the research question of the BEST plots: How can we grow our fuel and save our flowers and butterflies, too?
2. Focus on the first part of the research question “How can we grow our fuel?”

(also in PowerPoint presentation)

* 1. We planted two kinds of plants: prairie and switchgrass
     1. Our prairie mix contains 16 species of native prairie plants (one of which is switchgrass)
     2. Switchgrass plots only have 1 species of plant
  2. Introduce the term “biomass”, which is the dried weight of plants and is a way we can estimate how much fuel plants can make. (Of course, there is much more to the process of making fuel, but biomass is a good estimate, especially as a relative estimate between two plant types.)
  3. Have students think about which plant type might grow more biomass. Have them consider why each plant type might do better. Students often think they were “wrong” if their individual predictions don’t match the data. One way of emphasizing the idea of competing hypotheses is to discuss as a class until students generate reasonable predictions on both sides.

1. **Play a game to get insight into the biology of plants and competition for nutrients.** This will help students make a prediction. (also in PowerPoint presentation)
   1. All plants compete with each other for nutrients. Plants need nutrients to grow. More plant growth means more biomass we can use for fuel.
   2. This game gets students thinking about the question, “How might competition for nutrients be different in plots of switchgrass versus plots of prairie?”
   3. Set up teams with 4-6 people, and the number of people per team should be as close to the same as possible.
   4. You also want an even number of teams because half of the teams will represent plots of switchgrass and half of the teams will represent plots of prairie.
   5. Each team gets
      1. a black textured mat
      2. an equal number of nutrients of each type (we used 5 nutrients of each type)
      3. nutrient types = variety of objects of different sizes, shapes. We used two types of beads of different size & shape, foam pieces, small crumpled balls of paper, and paperclips.
      4. Because of the mat texture, some of the pieces will fall between the black rubber nubs and will be hard to get with certain tools.
   6. Team Switchgrass: each person gets 1 tool, all the same = magnet (but see later steps for variation in this tool)
   7. Team Prairie: each person gets 1 tool, all different = spoon, toothpick, fork, pipe cleaner, magnets.
   8. Other rules: You can’t roll any nutrients off the board; you have to pick it up with your tool. You can’t use your hands.
   9. Both teams play for 20 seconds, and each person tries to get as many nutrients as they can. Optional: collect nutrients in plastic cups.
   10. Write on the board how many nutrients each individual within each team collected.
       1. It’s important to look at individuals because it highlights differences in growth between individual plants.
   11. Looking at the data, discuss how all the prairie teams did compared to all the switchgrass teams.
       1. Is it clear which type of plant seems to get more nutrients and be able to grow more? (Feel free to play additional rounds to add more data to the pattern.)
       2. If switchgrass teams use the magnet, they can only pick up paperclips, so they are limited in the number of nutrients each plant can get. Prairie plants all have different tools, so each person isn’t as limited in the number of nutrients they can collect.
       3. Thus, we could predict that prairie plots will have more biomass because the variety of plants reduces competition for limited nutrients.
   12. Modification 1: Give switchgrass plants a different tool that can pick up many different types of nutrients, like the toothpick.
       1. Switchgrass and Prairie teams may perform relatively equally now.
   13. Modification 2: Give switchgrass plants a different tool that is very good at getting any nutrients, like a pair of tweezers.
       1. Switchgrass will perform very well, because they can use a variety of nutrients *and* because it’s easier to pick up nutrients with tweezers than with other tools. This would make switchgrass a very good choice as a biofuel.
   14. Optional: Practice taking averages and plotting data.
       1. Average the number of nutrients of each Prairie team and the number of nutrients of each Switchgrass team.
       2. Make a bar graph on the board as a class (or students do this individually) with Plant type on the x-axis and Number of nutrients on the y-axis. (Note: the number of nutrients can be an estimate of how much a plant could grow and how much biomass it could produce.)
   15. Have students to come up with a prediction based on the game they played. Which plant type might grow more biomass?
2. **“How can we grow our fuel?”**
   1. Have your students complete the student version of the activity (in groups, individually, or as a class). (Note: there is a teacher version also available).
   2. Discuss the conclusions they made from the data.
   3. Does this agree or disagree with their initial prediction? Remind students that it’s perfectly acceptable if the results do not match their initial prediction. This happens all the time in science! The goal is to create a reasonable prediction based on what you know already and then design an experiment to test it. If your predictions were always supported by the data, then there wouldn’t be any point in doing the experiment. Boring! (And then there would be no jobs for scientists!)
   4. Consider returning to the PowerPoint presentation to look at a few additional graphs of data related to this question of which plant types make more biomass. Discuss how these additional graphs give new insight into the patterns and conclusions.
      1. The first graph shows that Prairie has a few more species on average compared to Switchgrass, but what we planted was 16 species in Prairie and 1 in Switchgrass.
         1. What accounts for the difference in what we planted and what grew in the plots? (What seeds were already in the soil? What plants are growing near the plots that could send seeds into the plots (i.e., volunteer plants)?
         2. How does the difference in average number of species relate to the game and the prediction we made based on the idea that prairie had many species while switchgrass only had one? (The actual data suggest that competition for nutrients could be much more similar in these plots compared to what we modeled in the first version of the game.)
      2. The second graph shows lots of variation in the amount of biomass at each school. (Students could also see this variation in the data table)
      3. The third graph shows how much biomass Prairie and Switchgrass have at each school. There is lots of variation!
      4. These two graphs can illustrate why it is important to repeat experiments. You can get lots of variation, and when you put all the data together, you get a better and more accurate idea of what is going on than if you only looked at the plots from one school.
3. **Other questions your students can ask using the BEST data:**
   1. How does soil moisture affects how much plants grow (biomass)?
   2. How does plant growth (biomass) affect diversity of invertebrates?
   3. How does the diversity of plants affect the diversity of invertebrates?
      1. Note: You can also use the game to model predictions for this question. See “Modifications and Extensions” below.

**Resources**

* A standalone introductory lesson focused on bioenergy with some similarities to this lesson

Main page: <http://kbsgk12project.kbs.msu.edu/blog/2012/03/20/best-plots-lesson-plans-2>

Lesson: <http://kbsgk12project.kbs.msu.edu/wp-content/uploads/2011/09/Bioenergy-Introduction-Lesson-Plan.doc>

Presentation: <http://kbsgk12project.kbs.msu.edu/wp-content/uploads/2011/09/Bioenergy-intro-updated-2.7.11.ppt>

* These activities were created based on the Data Nugget model. Data Nuggets give students practice interpreting quantitative information and making claims based on evidence. Students are challenged to answer a scientific question using data to support their claim, and are guided through the construction of graphs to facilitate data interpretation. Because of their simplicity and flexibility, they can be used throughout the school year as students build confidence in their quantitative skills.

<http://datanuggets.org>

* Another cool lesson using data, graphing, and interpretation for grades 9-12 on the topic of amphibian migration (from the University of Connecticut).

<http://hydrodictyon.eeb.uconn.edu/people/urban/teachers/lesson_plan.pdf>

**Extensions and Modifications**

Use the game to model how plant diversity could affect invertebrate diversity (worksheet is available to address this question, too). In this scenario the objects on the mat are plants in the environment and the students are invertebrates feeding on the plants. Set up some mats with a variety of plants (e.g., paperclips, beads, foam pieces, crumpled paper) and other mats with only one variety of plants (e.g., paperclips). Then let the invertebrates feed on the plants. Imagine that invertebrates need to eat a certain number of plants to survive. One possible outcome that matches biological reasoning is that more diverse plant communities are likely to support more diverse insect communities.

You could also play the game outside of the context described here and model what happens with invasive and native species. In this scenario, you set up the mats and nutrients as described in the first version of the game. All of the teams have a variety of plants in them, so each person gets a different tool. But some students are the invasive plant, which gets a tool (tweezers) that is excellent at getting nutrients from the environment and can outcompete native plants.

**Assessment**

Use the worksheets to assess students’ understanding of making predictions, describing and interpreting patterns in data, and explaining results using evidence. See the teacher version of each activity for grading.