Farming for Beetles, Bees and Biomass

Overview: What effect does growing millions of acres of corn have on the plants and insects living in agricultural landscapes? Can we balance biomass production and biodiversity by using a variety of bioenergy crops? In this "data dive" students analyze data on the biodiversity of plants and beneficial living in different bioenergy crops. They also compare some of the important ecosystem services that bugs and plants provide in different crops and explore ways balancing the tradeoffs between producing biomass and maintaining some of the valuable benefits of biodiversity in farming landscapes.

Levels
Middle and High School (7-12)

Subjects
Biology, Environmental Science, Earth Science, Agriculture

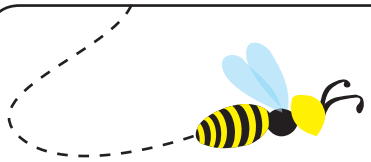
Objectives
- Identify the variables in an ecological research experiment
- Explain how biodiversity is measured by ecologists
- Describe some of the ecosystem services provided by plants and insects
- Analyze and interpret data on biodiversity and ecosystem services
- Evaluate the tradeoffs associated with growing different crops for biomass production, biodiversity conservation and ecosystem services

Materials
Farming for Beetles, Bees, and Biomass Data Dive Activity Package

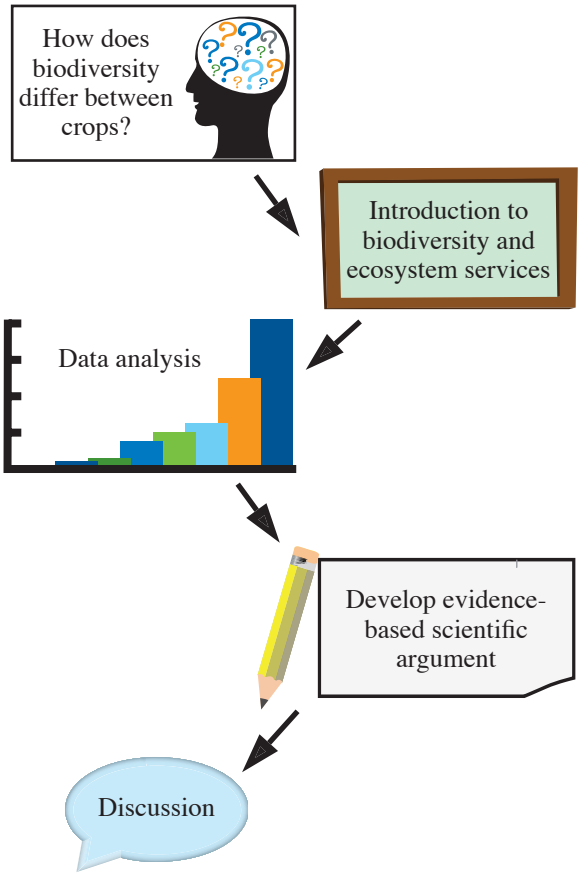
Activity Time
Two 50-minute class period

Standards
Next Generation Science Standards (2013)
- MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity
- HS-LS2-7. Design and/or refine a solution for reducing the impacts of human activities on the environment
- HS-LSS3-3. Illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity
- See page 2-3 for full details.

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



Crop	Plant Richness	Insect Predator Richness	Bee Richness
Corn	10.9	2.9	16.0
Switchgrass	14.7	11.6	27.7
Prairie	21	14.6	22.2



GLBRC Data Dive: Farming for Beetles, Bees and Biomass

Overview: In this "data dive" students analyze data on the biodiversity of plants and beneficial living in different bioenergy crops. They also compare some of the important ecosystem services that bugs and plants provide in different crops and explore ways balancing the tradeoffs between producing biomass and maintaining some of the valuable benefits of biodiversity in farming landscapes.

Learning Outcomes: Students will…

- Identify the variables in an ecological research experiment
- Explain how biodiversity is measured by ecologists
- Describe some of the ecosystem services provided by plants and insects
- Analyze and interpret data on biodiversity and ecosystem services
- Evaluate the tradeoffs associated with growing different crops for biomass production, biodiversity conservation and ecosystem services

Suggested Background Knowledge: This lesson assumes some familiarity with the scientific method, hypothesis testing, graphing (if students are asked to create their own), graph interpretation, and basic statistics. In addition, familiarity with the definition of a species, definitions of biodiversity, and some knowledge of species interactions (predation, competition, etc) is helpful.

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

Middle School:

- **MS-LS2-5**. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

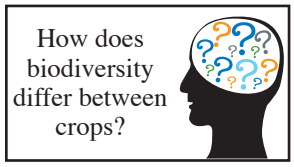
High School:

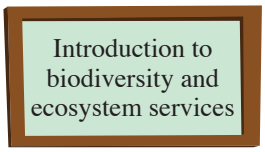
- **HS-LS2-2**. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

NGSS Standards (cont.):

- **HS-LS2-7**. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- **HS-LS4-6**. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
- **HS-ESS3-3**. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Activity Sequence:





Part 1: Background and biodiversity data analysis (50 minutes)

1. Before the activity (optional): Have students read and discuss the "Entomology Detectives" Research Story for a deeper introduction into how researchers investigate the valuable services that beneficial insects provide farmers. See: https://www.glbrc.org/education/classroom-materials/research-story-entomology-detectives
2. Have students read the 1-page "Research Background" reading. Have students identify the scientific questions behind the research. Have students share their definitions of biodiversity and ecosystems services based upon the reading.
3. Use the accompanying presentation slides to review the context for the research, the key terms, and the methods that the ecologists used to measure biodiversity and ecosystem services.

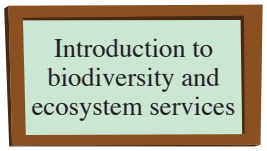
4. Hand out and have students complete Part 1 of the student worksheet analyzing the biodiversity results (questions 1-2). Have students compare and discuss answers in pairs or small groups. Depending student level, they can either interpret a bar graph or make their own. The activity package includes three worksheet options:
    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. Pool answers and summarize conclusions as a class. Discuss avenues for future research and factors that might be affecting the biodiversity in different crops.
6. Have students complete questions 4 and 5 from Part 1 comparing and discussing answers in pairs or small groups. Alternatively, these questions could be answered and discussed as a class using the accompanying slides.

7. Pool and discuss ideas of potential ecosystem services provided by different types of organisms (student responses to question 4).
8. Pool student ideas about which crops with have the highest ecosystem service values (responses to question 5).

Activity Sequence, Continued

Part 2: Comparing ecosystem services and balancing tradeoffs (50 minutes



1. Hand out Part 2 of the student worksheet.
2. Have students complete question 1 identifying the research question related to ecosystem services from the Background Reading.
3. Use the accompanying presentation slides to review the context for the research, the key terms, and the methods that the ecologists used to measure biodiversity and ecosystem services.

4. Have students complete questions 2-4 which guide them through analyzing and interpreting the data.
5. Pool answers and guide the class toward coming to a consensus statement about the differences in ecosystem services between each crop. Given the complexity of the data. It could be helpful to write one statement for each ecosystem service. For example, on average prairie produced 17 g/m2 (2.6%) more biomass than switchgrass, but is this significant for a farmer? Would we be confident that we would see this difference if we repeated this study? Comparing the difference between numbers on a percent basis can be helpful for getting a sense for whether the difference is significant from farming and statistical perspective.
6. Discuss answers to question 3 and possible reasons for differences between actual and expected results. See notes in the answer key for possible answers and ecological principles that are behind the differences.

7. Reviewing question 4 provides the opportunity to discuss how ecologists can make educated guesses about expected results based upon patterns seen in existing data.
8. In small groups and/or as a class, have students answer and discuss questions 5 and 6. There are many potential solutions to helping balance the tradeoffs between supporting biodiversity and producing biomass. If

students can't think of any, bring up the idea of putting a monetary value on the pest suppression and pollination services provided by insects. As follow-up, ask students what crops they would choose to plant if they owned a farm with two fields. This provides the opportunity to discuss how individual and societal values affect our decisions.

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 complete the Growing Energy "Data Dive" comparing biomass yields between different crops.
3. Have students conduct their own schoolyard investigations into plant and bug biodiversity using the Fields Investigations: Bug Biodiversity and Ecosystem Benefits lesson.
4. Explore the importance of insect biodiversity for ecosystems and our economy with the Dividends from Diversity lesson created by educators at the W. Kellogg Biological Station.
5. Delve deeper into the concept of ecosystem services and how farmers can maximize them with the Farming for Ecosystem Services lesson created by educators at the W. Kellogg Biological Station.
6. Advanced students can delve into comparing additional biodiversity and ecosystem services data from this study for birds, microbes, etc. See the original research paper and supplementary data included with this activity package.

References. This activity is based upon the follow research study:

Werling, B. P., T. L. Dickson, R. Isaacs, H. Gaines, C. Gratton, K. L. Gross, H. Liere, C. M. Malmstrom, T. D. Meehan, L. Ruan, B. A. Robertson, G. P. Robertson, T. M. Schmidt, A. C. Schrotenboer, T. K. Teal, J. K. Wilson, and D. A. Landis. 2014. Perennial grasslands enhance biodiversity and multiple ecosystem services in bioenergy landscapes. Link to full text article: PNAS 111: 1652-1657

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/

Biodiversity and ecosystem services data for this activity was provided by Dr. Ben Werling, Michigan State University Extension Educator and Entomologist.

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