Field Investigations: Bug Biodiversity & Ecosystem Benefits

Overview: Student field investigations to explore the effects of biofuel crop production on invertebrate diversity and the effects those organisms have on pollination rates and weed seed predation. Teachers can choose from a suite of six field-sampling methods for investigations of school-yard biofuel plots, agricultural fields or existing natural communities.

Levels
K-Undergraduate

Subjects
Science, Environmental Studies

Objectives
- Design, conduct and analyze an experiment to measure biodiversity and/or invertebrate ecosystem role in a field community.
- Describe the role of insects and other invertebrates in a field ecosystem.
- Explain how land management practices (tilling, fertilization, etc) and different plants (prairie, grass, etc) have an effect on invertebrate activity levels and biodiversity.

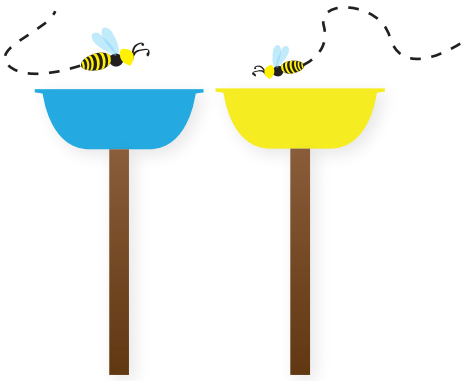
Materials
Field Investigations: Bug Biodiversity & Ecosystem Benefits package

Activity Time
Variable three to five 50-minute class periods

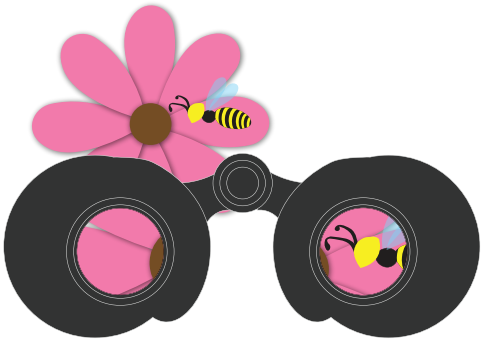
Standards
Next Generation Science Standards (2013)
- Scientific and Engineering Practices: asking questions and defining problems; planning and carrying out investigations; analyzing and interpreting data; constructing explanations and designing solutions
- Disciplinary Core Ideas: ecosystems; biological evolution
- Crosscutting Concepts: patterns; cause and effect; stability and change
- 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

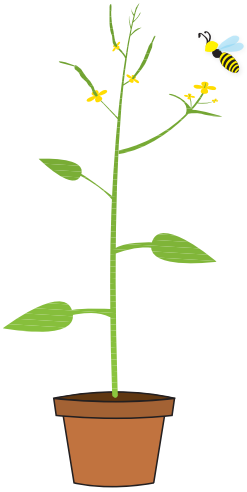
Bee Sampling Using Bee Bowls



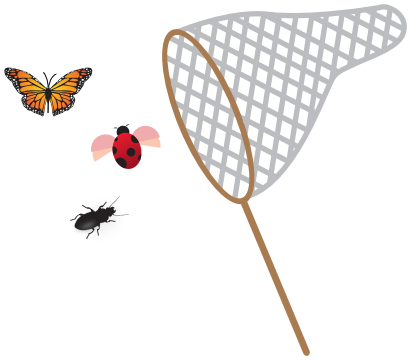
Estimating Pollinator Activity With Observations



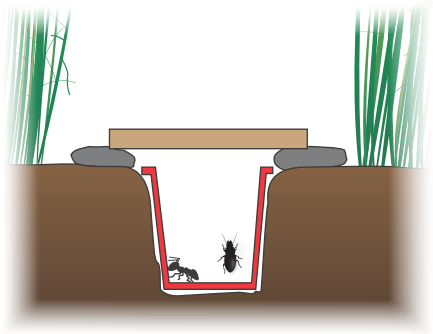
Estimating Pollinator Activity With Potted Plants



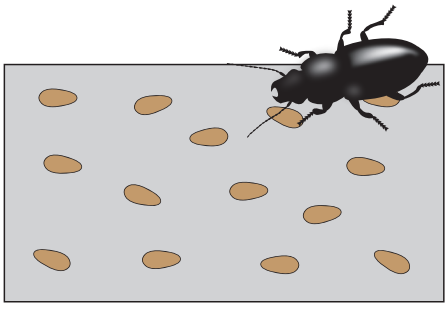
Sampling Invertebrates with Sweep Nets



Sampling Ground Invertebrates with Pitfall Traps



Estimating Weed Seed Predation by Ground Invertebrates



For Teachers: Field Investigations: Bug Biodiversity & Ecosystem Benefits

Overview:

Student field investigations to explore the effects of biofuel crop production on invertebrate diversity and the effects those organisms have on pollination rates and weed seed predation. Teachers can choose from a suite of six field-sampling methods for investigations of school-yard biofuel plots, agricultural fields or existing natural communities.

Learning Outcomes: Students will...

- Design, conduct and analyze an experiment to measure biodiversity and/or invertebrate ecosystem role in a field community.
- Describe the role of insects and other invertebrates in a field ecosystem.
- Explain how land management practices (tilling, fertilization, etc) and different plants (prairie, grass, etc) have an effect on invertebrate activity levels and biodiversity.

These lessons can be modified to meet a wide range of student backgrounds and abilities. Some prior knowledge in experimental design is helpful.

Related GLBRC Activities: The following activities can be paired to help students see connection to real-world problems and research questions

- *Entomology Detectives (Research Story)*: Reading and discussion about how entomologists are using video surveillance to discover beneficial bugs are visiting bioenery crops.
- *Farming for Beetles Bees and Biomass (Data Dive)*: Data analysis and interpretation activity to evaluate the biodiversity benefits of different bioenergy crops using real GLBRC data.

Learn more and download activity packages here: https://www.glbrc.org/education/classroom-materials

Standards

Next Generation Science Standards (2013)

Elementary School:

- **2-LS4-1**. Make observations of plants and animals to compare the diversity of life in different habitats.

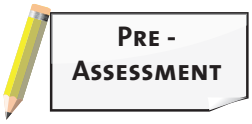
Middle School:

- **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-LS2-2.** Construct an explantation that predicts patterns of interactions among organisms across multiple ecosystems.
- **MS-LS2-5.** Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

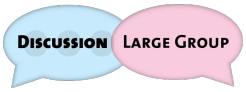
High School:

- **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.

Sequence:



Part 1. Pre-Assessment & Discussion (up to one class period)
Each activity has a different focus and procedure. Determine which activity you would like to run and use the sample questions and summary to lead a discussion to learn what students know about the topic. In all cases, one focus is to discuss the role of invertebrates, such as insects and spiders, in a healthy ecosystem. Why do we want bees? Why do we want more than one species of pollinator? Find out if students have experience collecting and identifying insects, or if they have made other types of collections. You may want to discuss how to categorize invertebrates, or the term *morphospecies* (described in the appendix). The appendix contains suggested background



"Biodiversity Front Newsletter"

readings if you would like to provide students with more specific information. The *Biodiversity Front Spring 2010 newsletter* written by GLBRC scientists, included in supplementary materials, provides a short introduction to this research area.

Be sure to find out if any students have bee sting allergies or other medical issues that would restrict their ability to participate in field activities.

Part 2. Experimental design (pages 1, 18 and corresponding Field Instructions pages) (up to one class period)

Decide which of the techniques you will make available to students, and hand out the appropriate *Field Instructions* page(s). As a class, or in groups, read through the handout and choose a question or write a new one to investigate. Most questions will be a variation on the following ideas:

- Which invertebrates inhabit and/or utilize a particular bioenergy crop field?
- Does the invertebrate population in one field affect the health of the ecosystem in an adjacent field?
- Do land management practices affect the invertebrate community?

With planning, different class groups could conduct many of the activities simultaneously or on the same field trip. However, please note that each activity requires different amounts of preparation, field time and follow-up analysis time. The basic procedures are described on the *Field Instructions* pages, but the class should discuss where to sample, when to sample, what to compare, number of replicates, how to collect data, and how to behave in the field to reduce disturbance. Page 1 provides a guide for *Experimental Design*. Students should develop a hypothesis based on their understanding of how the system functions.

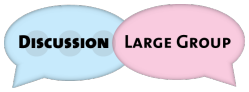
The *Site Description* page should be completed for all studies, although you may not need to fill in all information on the page depending on your focus and available resources. Students can be involved in deciding which items to complete and which are unnecessary.

Use the references in the appendix to help with identification as well as techniques for collecting and preserving invertebrates.

Part 3. Conduct experiment (varies).

"Sample graphs for field investigations"

Part 4. Data Analysis and Discussion (page 2) (1-2 class periods)
Once you count your invertebrates and pool your class data, compare diversity and abundance in your different habitats by calculating averages and standard deviations and/or by creating bar and whisker graphs. Sample graphs from actual field studies are provided in the supplementary materials folder. For more advanced students use a statistical test, such as a t-test (two habitat types) or an analysis of variance (two or more habitat types), to determine the likelihood that observed differences between habitat types are due to chance.



Use the *Data Analysis and Discussion* page to help students summarize the results. Students will describe how the evidence collected during their experiment supports or refutes their hypothesis. What have they learned from this investigation and what would they still like to know? Return to your original discussion of the role a diverse invertebrate community plays in a healthy ecosystem. How might we use this information to make recommendations about growing crops for biofuels?

Extensions: Download the following activities from the GLBRC website.

1. *Entomology Detectives (Research Story)*: Reading and discussion about how entomologists are using video surveillance to discover beneficial bugs are visiting bioenery crops.
2. *Farming for Beetles Bees and Biomass (Data Dive)*: Data analysis and interpretation activity to evaluate the biodiversity benefits of different bioenergy crops using real GLBRC data.
3. *Biomass Yield and Carbon Cyclin g in Crops*: Conduct field investigations looking at carbon cycling through the same community

Answers to Discussion Questions

3. Sketch or describe the role invertebrates play in the communities you investigated. Use morphospecies names where possible.

Students might draw a food web appropriate for this ecosystem, or describe how pollinators visit specific plants in the community, or how certain insect species control the population of specific weeds.

4. Farmers are starting to consider using fields to grow crops for biofuels. How might we use the information from these field investigations to make recommendations about growing crops for biofuels?

Farmers may want to consider plantings that attract beneficial insects to their fields. These insects can provide pollination services for key crops the farmer may have elsewhere on his property. Some invertebrates also serve as herbivore predators, reducing the need to purchase and use pesticides. Since certain monocultures, like corn, might be more profitable for farmers, they might consider breaking their field into a patchwork of plantings to provide a home for beneficial insects that "work" in food crop fields. Students might also think about adjusting the time of harvest so as not to disturb certain insect populations. The insects found in these studies are part of a larger food web, providing food for birds, mammals and other animals. What would happen to the landscape without invertebrate diversity?

Appendix:

Definitions:

Morphospecies - A way to classify any organism by general physical characteristics. For insects, people often start with insect orders (e.g., beetles, bugs, butterflies), but then they may subdivide orders into finer categories based on characteristics like size, color, shape of antennae, or venation of wings. Your class can decide what categories to use for morphospecies,

especially in more advanced classes. What is most important is consistency and agreement on what makes an organism fit one category vs another. Morphospecies categories can be determined after collection is finished and be done as an exercise in itself.

Useful References:

"Bug Guide." 2005. Iowa State University Extension.
http://bugguide.net/node/view/15740
Arthropod identification.

Online Wisconsin Wild Bee Guide. 2013. Wisconsin Energy Institute.
http://energy.wisc.edu/bee-guide/
Online key with nice photos to help you ID wild bees.

"Collecting and Preserving Insects." 2005. J. Hahn, University of Minnesota Extension.
http://www.extension.umn.edu/distribution/youthdevelopment/da6892.html
Insect collecting and pinning instruction.

"The Ground Crew." 2001. J. Meyer, NC State University.
http://www.cals.ncsu.edu/course/ent525/soil/index.html
Invertebrate identification (especially for soil invertebrates).

Wisconsin Fast Plants
http://www.fastplants.org/
Plants can be grown easily for estimating pollinator activity.

Related Readings and Videos:

Video: Bugs, Beetles, Bees and Biofuels.
http://www.youtube.com/watch?v=1EfznQBdNN4#t=11
Meet Claudio Gratton, UW professor of entomology, as he discusses the importance of bug diversity for sustainable biofuels.

Dale, V., K. Kline, et al. 2010. Ecological Society of America. "Biofuels: Implications for Land Use and Biodiversity."
http://www.esa.org/biofuelsreports/files/ESA%20Biofuels%20Report_VH%20Dale%20et%20al.pdf

This report provides a thorough scientific summary of the issues associated with biofuel crop production, and corresponding potential changes in land-use and biodiversity. Appropriate for high school and college students.

EPA. 1999 "Biodiversity and Ecosystem Functioning: Maintaining natural life support processes. " Issues in Ecology.
http://www.esa.org/esa/wp-content/uploads/2013/03/issue4.pdf

A short paper on the relationship between how ecosystems function and the need for biodiversity to maintain those functions.

"Meet the Natives: Wild Bees." 2013. Eleanor Nelson, Quest Wisconsin.
http://science.kqed.org/quest/video/what-can-insects-teach-us-about-sustainability/

A video story on UW entomologist Claudio Gratton and his research into native bee species in Wisconsin's prairieland. The article explores the troubles facing this major pollinator.

Werling, B.P., et al. 2012. "Biodiversity Services and Bioenergy Landscapes"
http://www.landislab.ent.msu.edu/_files/PDFs/Werling%20et%20al.%20Biodiversity%20Services%20Bioenergy%20Landscapes%20bulletin%20E-3164.pdf

This Michigan State University Extension bulletin provides a great overview of the biodiversity ecosystem services in agricultural landscapes and connections to sustainable bioenergy crop production.

DOE Bioenergy Research Centers

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