NATURE LAB Educator Resources

GARDEN LESSON PLAN: HABITAT AND POLLINATORS

Many elements are interconnected and function together to create the natural and productive living system that is your garden. Look to the end of this activity guide for additional lesson plans, activity guides, and videos that can help you bring together soil, water, habitat, food, and community to explore your dynamic garden ecosystems.

Subject Area: Gardens, General Science

Grade Levels: Geared toward 6th-8th grade, but can be tailored for all grades

Essential Question:

How does a garden model an ecosystem?

Purpose and Overview:

In this activity, students conduct a species census to identify species within the garden habitat and observe their interactions with one another and their environment, focusing in particular on the role of pollinators. Through repeated observation and data collection, students determine which species inhabit the garden, investigate relationships among them, and identify factors that may affect them. By tracking species over a period of time, students may discover patterns in biodiversity related to changes in the garden habitat. Ultimately, students will learn how a garden functions as an ecosystem and will be able to describe that the greater the diversity of plant and animal life in the garden, the more effective the garden is as an ecological system, and the better able it is to help keep nature resilient and productive.

Time:

This activity guide is part of an extended learning experience that engages students in creating and maintaining a school garden. The following are suggested time allotments for each section of the guide.

- **Engage:** one 45-minute class period
- **Explore:** one-two 45-minute class periods depending on the size of your garden

- **Explain:** two to four weeks for data collection
- **Evaluate:** one 45-minute class period
- **Extend:** allow at least one 45-minute for each of the activities suggested in this section of the guide

Materials and Resources:

Materials for teacher:

- Computer with Internet connection
- Dry/Erase whiteboard with stand (optional)

Materials for each student or group of students:

- Garden Project Notebook and pencils
- Computer with Internet connection
- Digital camera or mobile device for taking photos
- Access to printed and online field guides, such as:
    - *Beneficial Insects, Spiders, and Other Mini*-Creatures in Your Garden - https://pubs.wsu.edu/ItemDetail.aspx?ProductID=15656&ReturnTo=6
    - Petersen or Audubon guides
    - *The Cornell Lab of Ornithology - All About Birds* - https://www.allaboutbirds.org/
    - *BugGuide* - https://bugguide.net/
    - *eNature.com* Field Guides - https://web.archive.org/web/20161025011802/enature.com/fieldguides/
- Handouts listed below can be found here: https://www.natureworkseverywhere.org/resources/activity-guide-habitat/
    a. Habitat Field Report
    b. Habitat Data Analysis
    c. Habitat Evaluation

***Nature Lab* videos supporting this activity guide:**

- *Pollinators – Putting Food on the Table* https://vimeo.com/77811127
- *Global Gardens* - https://vimeo.com/77792707
- *Coral Reefs – Feeding and Protecting Us* - https://vimeo.com/77811130

Gardens How-to Video Series:

- *Planning Your Garden* - https://vimeo.com/91446626
- *Building a Garden in a Day* - https://vimeo.com/91445078
- *Caring for Your Garden* - https://vimeo.com/92520693
- *Fears in the Garden* - https://vimeo.com/92531513

Objectives:

The student will…

Knowledge

- Define the concept of a habitat.
- Define the concept of species within a habitat.
- Define the concept of biodiversity.

- Understand how biotic and abiotic factors interact as a system within a habitat.
- Review the process of pollination and the role of pollinators within a habitat.

Comprehension
- Observe and identify species found in the garden.
- Describe plant characteristics that tend to attract one type/species of pollinator.

Application
- Identify, record, and estimate the number of species present in the garden habitat during regular intervals of time.
- Identify plants with characteristics that are most likely to attract one type/species of pollinator.

Analysis
- Describe the relationship between habitat and biodiversity in the garden.
- Describe the effects of pollinator behaviors in the garden habitat.
- Develop an argument that specific plants will provide habitat and food for a specific type/species of pollinator.

Synthesis
- Generate ideas and list factors that may affect biodiversity.
- Review habitat data and garden design to determine which factors impact the degree of biodiversity present over time.
- Develop a theory for how biodiversity makes nature resilient and productive.

Evaluation
- Judge the effectiveness of the school garden to support biodiversity.
- Evaluate if and/or how the garden can support greater biodiversity.
- Evaluate how a garden models an ecosystem.
- Evaluate how greater biodiversity of flowering plants affects the biodiversity of pollinators in the garden.

Next Generation Science Standards:

Disciplinary Core Ideas:
- LS1.B Growth and Development of Organisms
- LS2.A Interdependent Relationships in Ecosystems
- LS2.B Cycle of Matter and Energy Transfer in Ecosystems

Crosscutting Concepts:
- Cause and Effect
- Patterns
- Energy and Matter
- Stability and Change

Science and Engineering Practices:
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking

Performance Expectations:
Middle School

Activities in this lesson can help support achievement of these Performance Expectations:

- LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
- LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Common Core Standards:

6th-8th Grade Science and Technical Subjects

- CCSS.ELA-Literacy.RST.6-8.3 Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks.

Vocabulary:

Abiotic: The non-living elements (sunlight, water, rocks, etc.) that are a part of and interact with biotic factors in an ecosystem.

Biodiversity (short for "biological diversity"): The variety and quantity of life found in a given environment. Generally, the greater the biodiversity found within an ecosystem, the healthier the ecosystem.

Biotic: The living organisms found within an ecosystem.

Citizen Scientists: Volunteers who collaborate with scientists on research projects, especially those involving scientific data collection.

Habitat: The natural home or environment of an animal, plant, or other organism.

Invasive Species: A non-native species whose presence in an ecosystem causes environmental, ecological, or economic harm.

Monoculture: The cultivation or growth of a single crop or organism, especially on agricultural or forest land.

Organism: An individual form of life such as a single plant, animal, bacterium, or fungus.

Pollination: The transfer of pollen from the male anther to the female stigma of a plant.

Pollinator: The agent (living or non-living) that moves pollen from the male anther to the female stigma of a plant.

Species: A group of animals or plants that are similar and can reproduce; smaller than genus.

Species Census: A systematic count of the species and members of each species observed within a specified area or from a specified location.

Stressors: A chemical or biological agent, environmental condition, external stimulus, or event that causes stress to an organism.

Taxonomy: The science of defining groups of organisms on the basis of shared characteristics and giving names to those groups.

Engage

1. Have students create a list of organisms they have noticed in the garden.

2. Discuss the lists with students. Possible discussion points include:
   - Why do you think you've seen these organisms in the garden?
   - Is there a scientific explanation for their presence?
   - Which came first, the animals or the garden?

3. Explain that the garden is not only a home for plants but also a habitat for animals, a habitat that students have helped to create but which ecological processes, including the presence of biotic (living) and abiotic (non-living) factors, work to sustain.

4. Students will conduct a habitat survey in the garden to find out what species are part of this habitat and how they interact with one another and the garden environment.

5. Types of data to be collected:

   a. Class and Date: If there are several classes participating in your school's garden project, choose the appropriate class name and enter the date on which your students made their observations.
   b. Quantity: For each animal that students observe, how many do they see?
   c. Organism: Type in the animal's common name — for example, earthworm, honey bee, lady bug, ruby-throated hummingbird, chipmunk.
   d. Type: What kind of animal is it? The drop-down menu includes both specific types — bee, beetle, butterfly, dragonfly, grasshopper, moth — and general types — other insect, bird, mammal, other organism, etc.
   e. Notes: Use this text box to add your students' observations on where they saw the animal and its behavior.
   f. Photos: Explain that you will be able to upload the students' photos of animals they observe in the garden. Determine the most suitable method for the students to give you the photos.

6. As a discussion or writing prompt, ask students:

   What is the benefit of having lots of different kinds of organisms (biodiversity) in a habitat like the garden? Why is more biodiversity generally preferable in regard to the health of an ecosystem?

a. To prompt students, remind them of what they have learned about food webs and food chains. What can happen if a species disappears from a food web? (The plants and/or animals that the missing species feed on may multiply and disturb the balance of the ecosystem, while the animals that feed on the missing species may also disappear, disturbing the ecological balance further.) By contrast, what happens when there are many different species in the food web? (More species increases the number of potential food sources for other animals in the food web, particularly if there are more species at every level of the food chain, and makes the ecosystem more resilient and adaptable to fluctuations in the population of any one species.)

b. Remind students also of the role certain animals play in the ecology of the garden. Ask: Why would we want lots of different kinds of bees and wasps and butterflies? Students should recall (from the Living Systems activity guide) that these animals are pollinators that play a crucial role in plant reproduction. The more diverse kinds of pollinators there are, the more likely the plants will be pollinated, since species are attracted to different types of plants.

c. Also ask students to think about how biodiversity can keep an ecosystem healthy, productive, and strong. Why would an array of plants and animals in any habitat keep that habitat healthy and strong? To illustrate this point, ask students to think about a monoculture — the cultivation or growth of a single crop or organism — such as a corn field. In a monoculture, only one type of plant is produced. What happens if a pest or disease attacks this monoculture? If the pest or disease is strong enough, the entire monoculture, a field of corn in our example, can be wiped out. When a habitat or living system is diverse, however, that habitat is composed of many species and is therefore able to withstand attack from pests or disease. In our example, if the singles species (corn) is wiped out, the entire habitat suffers, whereas a habitat that is composed of many different types of plants, including corn, can survive an attack by pests or disease – The corn may be gone, but the system isn't composed entirely of corn, so the system (the habitat) itself remains alive.

7. Conclude by returning to your list of animals that students have noticed in the garden. Count the different species represented on the list, and then ask students to forecast how many more species they will find when they begin to observe the garden systematically. Reach a consensus and set this number as a hypothesis for your species census.

Explore

Data Collection Preparations

1. Explain to students that they will be gathering data on animals in the garden by conducting a species census. This means they will be looking very closely and carefully at every part of the garden, taking notes on the different animals they see, and counting how many they see of each different kind.

   NOTE: At this point, you should ask if any students know they are allergic to bee stings and take appropriate precautions to keep those students safe.

2. Tell students that by conducting a species census they will be practicing important skills that scientists use to study biodiversity. By identifying and counting the animals in a specific habitat, scientists monitor species populations to determine if *stressors* – such as drought, competition from other species, or pollution - are threatening a species. It's this kind of scientific field work that enables scientists to identify endangered species, like the Giant Panda in China and the Island Fox in California and take steps to protect them. Scientists often get data from volunteers when they conduct a species census, and it could be that someday a scientist will take data from the students' species census to study the effect of school gardens on biodiversity. In this way, students may eventually contribute to the work of what are called "citizen scientists" — ordinary people who collect data to help scientists with research.

3. To prepare students for their species census, distribute copies of the Habitat Field Report, or create your own in a garden journal, and review how students will use this chart to record data on organisms in the garden. Point out that students will be collecting other kinds of data in addition to the data they will be reporting could be:
   a. **Organism:** Write in the common name of the animal you observe. If you don't know the name, leave this space blank and take a photo of the animal or describe it in the Notes column. You can look up the name later in a field guide.

   b. **Quantity:** Keep a count for each different animal. For example, if you see an earthworm, write down 1; then, if you see another earthworm, change your number to 2. Try not to count the same animal twice. Some animals are hard to count, like ants. If you can't count all the animals, make a guess or write "lots."

   c. **Type:** Use the code at the bottom of the chart to identify the type of animal you have observed. These are the same types listed on the website.

   d. **Where Observed:** Describe where you observed the animal. Try to include both the general location (for example, "in the tomato patch" or "in the shade of the maple tree") and exactly where the animal was when you saw it (for example, "crawling on a stem" or "sitting on the bark of the tree trunk").

   e. **Role:** Some animals play a special role in the garden's ecology. Use the code at the bottom of the chart when you observe an animal that plays one of these roles:
      - Pollinators are animals that spread pollen by flying from flower to flower or by crawling into and out of different flowers. Many pollinators are insects, but many birds, such as hummingbirds, can pollinate plants as well.
      - Decomposers, usually found in or on the soil, are animals that feed on and help break down decayed organic matter. They play an integral role in the health and productivity of the garden. Worms are an example of decomposers in the garden.
      - Invasive species are non-native organisms that are usually introduced to an ecosystem or habitat from an external source and can play a harmful role in the ecology of the garden. Invasive species can be plants or animals and may disrupt an ecosystem by dominating a region or particular habitat because of the loss of natural controls (predators or other factors in an ecosystem that keep populations of species in check). When introduced to a new ecosystem or non-native habitat, an invasive species can quickly multiply and dominate, negatively impacting native species, because their population is no longer controlled by predators or other factors. The Japanese Beetle is an example of an invasive species – the beetle was brought to North America

around 100 years ago, where it has no natural controls, and is a serious pest for about 200 species of native plants, including rose bushes, grapes and many species of trees.

- Pests also play a harmful role in the garden ecology, but mainly from the gardener's point of view. Aphids and scale insects, for example, which feed on plant sap, can be considered pests when they become so numerous that they weaken or kill a plant. Moles, which burrow through the soil and feed on earthworms, may be considered pests if their burrows disturb plant roots and slow their growth. Gardeners need to be aware of pests like these, so they can protect their plants, and students can categorize an animal as a pest if it seems to be damaging a plant.
- Note that students may not yet be able to identify the role of all the organisms they see in the garden. Let them know that if they make detailed notes of the organism's behavior and appearance, they will later be able to do research to learn more about each organism.

f. **Notes:** Students will use this space to describe organisms they will need to identify later and to take notes on animal behaviors — both how the animal interacts with the garden environment (for example, flying from flower to flower on a specific plant, hiding under a leaf, perching on a garden sign) and how it interacts with other animals (for example, attacking or eating another animal, running to hide from another animal). As they make these observations, students can evaluate how the animal's behavior fits into the garden ecology and what role the animal plays.

4. After you have reviewed the field report chart, take students online to become familiar with some of the field guides available for identifying animals they observe in the garden. Demonstrate how to use these guides by having students name or describe animals they already know to learn how these sites' search engines work.
   a. **Beneficial Insects, Spiders, and Other Mini-Creatures in Your Garden** This online guide, available as a pdf, provides information about how to attract and keep beneficial small organisms in your garden.

   b. ***The Cornell Lab of Ornithology - All About Birds*** website provides a searchable Bird Guide that is helpful if you know a bird's general name — for example, you think the bird is a sparrow but don't know what kind of sparrow. There is also a shape guide (www.allaboutbirds.org/guide/browse/shape) that is useful if you know what a bird looks like but don't know what it is. In addition, for students with smartphones, there is a free bird identification app, Merlin Bird ID that asks a few questions about the bird you are observing — size, color, etc. — and then shows pictures of birds that fit your description.

   c. ***BugGuide*** also provides a shape guide on the website's homepage and a search box at the upper right corner of the homepage where students can type in an insect name and see pictures of all kinds of insects that have that name — just click a picture to learn more. The *BugGuide* includes information about insects, arachnids (spiders, etc.), and myriapods (centipedes, etc.).

   d. ***eNature.com*** (still available via Internet Archive) offers field guides on many different kinds of animals — birds, mammals, reptiles, amphibians, butterflies, other insects, and spiders (plus trees, flowers, and other plants). The site also has a search page where students can select the type of animal they are trying to identify, answer a few questions about the animal's shape, size, and color, and see pictures of animals that fit their description.

5. As you explore field guide sites, you will find that most include catalogs that organize information on different animals based on *taxonomy*. This is the system that scientists use to identify and classify all living things, not just animals, based on similarities in their appearance, anatomy, and other factors. Taxonomy groups similar animals into smaller and smaller subsets, all the way down to individual species. It's a system that was developed in the 18th century by Carl Linnaeus, who introduced the practice of giving organisms "scientific names." These are usually Latin names composed of two parts, the genus name and the species name. For example, the scientific name for a robin is *Turdus migratorius,* which means that it belongs to the *Turdus* genus of birds and has the species name *migratorius*. Scientific names usually tell you something about the animal: *turdus* means "thrush" in Latin and *migratorius* means "to migrate," so this scientific name tells you that a robin is a migratory thrush. Students will find scientific names for every organism they identify with a field guide and can use these guides to learn the scientific names for organisms they may already know — like the robin. With practice, students may also learn to use the scientific catalogs on these sites to distinguish different species of organisms that look very similar and to search for organisms based on their scientific classification.

6. Finally, to prepare students for what they might encounter during your species census, show the *Fears in the Garden* video to help students address any fears they may have about the species census. Follow up by emphasizing that students should be extra cautious about observing bees and other stinging insects up close.

Collecting Data in the Garden

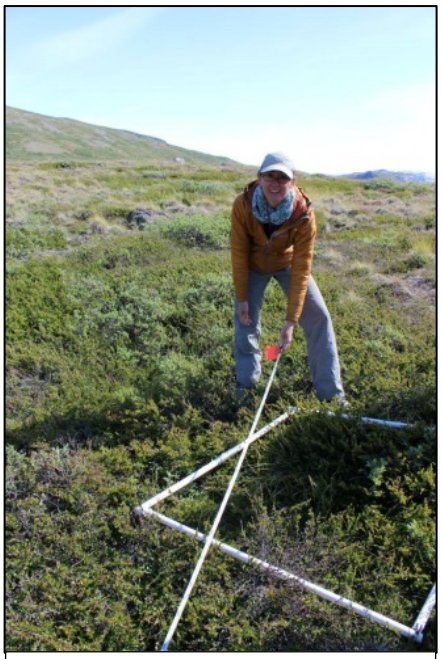
1. Schedule a day to begin your species census and plan the intervals you will use to collect data over time. Plan also to have students return to the garden as seasons change throughout the school year to gather new data that may reveal changes in the habitat's species population due to longer term environmental factors like trends in rain fall, weather, seasons, etc.

2. Organize students into pairs or small groups for your species census. If possible, each pair or group should have a digital camera or mobile device to photograph the species they observe.

3. Assign each student pair or group to a specific location or area within the garden. Explain that dividing the garden space in this way will help them look closely at every part of the habitat and make it less likely that they count a particular animal twice. Students can stick with their location assignments as you continue the census, or you can focus their observations in different ways: for example, have each pair search for and count organisms in a different square foot of soil; have them observe and count organisms on different plants; or position them around the garden perimeter to observe only organisms that enter and leave the garden. You can provide students with hula hoops to lay down and have them only count the species inside the hoop.

   Alternatively, your students can use transects and quadrats in the garden to mirror the way scientists might collect data in the field. This process will probably work best if you are focusing on insects and bugs since larger animals will be scared away. There are a variety of online resources to instruct you how to use this process. COSEE West has a lesson plan dedicated to using quadrats and transects in the field (https://web.archive.org/web/20140227203336/http://www.usc.edu/org/cosee-west/Dec2012/Activities and lessons/quadrat_transects.pdf) that you can reference.

To set-up transects in the garden, have student groups use tape measures, yarn, or another measuring device to mark out distances in the garden. Depending on the size the area, determine what interval makes the most sense. For example, students could lay the measuring tape and mark off every five feet with some kind of marker. If you are using quadrats, they can lay the quadrats bottom left corner at the mark (it doesn't matter where they lay the quadrat, but it must be consistent every time). Quadrats can be as large or small as makes sense for your space. If you are using quadrats made of PVC pipe like in the picture to the right, students must be careful not to injure plants when they place them. Alternatively, students can mark out permanent quadrats using string that they can come back to every time they collect data. This might take more time to set-up but will make data collection quicker during subsequent collection periods.



A scientist using a tape measure to make a transect in order to place a quadrat at specific intervals for a biodiversity study.
Photo credit: Britta Culbertson

4. Remind students that they are scientific observers and should not interfere with the animals they observe. No poking, teasing, grabbing, or swatting. Encourage students to show care for the garden and its inhabitants and let them know that scientists try to have the least possible impact on what they are observing so as not to interfere with the data and results of the data.

5. Give students a set amount of time to observe organisms within their assigned area or transect. They will likely see many organisms within a 10-minute period. They should use this time to observe and record organisms, their behavior, any characteristics that may be useful for identification, and any other information that seems notable.

6. Move among the student pairs to help them correctly fill in their Field Report charts. Explain that it is important that all students keep a detailed and complete record of what they observe – the more consistent and detailed you are in the data you collect, the more scientifically accurate and meaningful the data is. If you collect your data in a consistent way, you can then compare this data across time periods and to other data you have collected about your garden.

7. After each observation period, set aside time to work with students to identify any organisms they don't know and compile their data. Total up the number of organisms they observed — how many crickets, how many sparrows, butterflies, etc. — and select photos of each species to upload with your data. Have students share their notes on each species in a class discussion and help them pull details from these different observations to compose a class note on that species for your data report.

8. To help students assess biodiversity in the garden, have them also conducted a test species census in another natural area on the school campus. They will later compare the number of different species they observed at this test site with the numbers they observed in the garden. If their test site is a lawn or less diverse ecological area, they may find evidence that a wider diversity of plants, as in the garden, provides habitat for a wider diversity of organisms.

9. Students can use data collected on other elements of the garden like rainfall and water filtration to make hypotheses about how different elements of the garden affect one another.

   Possible questions for students:
   - Do you see more or fewer species in the garden when it has rained?
   - Are you experiencing an extended drought period?
   - How does this affect the species, in diversity and quantity, in the garden?

Explain: Data Analysis

1. Distribute the *Habitat Data Analysis* student handout. Have students work in their groups to analyze the data they have collected to learn more about the animals that live in the garden habitat.

2. Have groups present their data, keeping a general running tally on the board of different species and numbers. Have students use their observation notes to describe how the different animals and plants in the garden each contribute to the different ecological functions they have investigated — water filtration, food production, carbon cycling, and soil health. Help students recognize that the greater the variety of plants in a habitat, the greater the variety of animal species that are supported by it and the more productive it becomes in performing the functions of a living system.

3. Discuss how such diversity makes the garden habitat more adaptable and resilient, because the health of the ecosystem does not depend on the health of one or two plants and the animals they attract. Ask students to imagine scenarios in which a pest or disease or severe weather conditions (stressors) weaken or kill the plants in a non-diverse habitat such as a field of corn, an orange grove, or a rose garden (*monocultures*). What would happen in these ecosystems? Then have students use their species observations to suggest ways you might increase plant diversity within the garden, to create environments for more species.

4. For the ecological pyramid, you may want to display a large-scale blank version on the board or poster paper that students can add sticky notes to, each with the name of a species they found that they think belongs at a given level. (For an interactive introduction to ecological pyramids, visit *Virtual Lab: Model Ecosystems* at http://www.mhhe.com/biosci/genbio/virtual_labs/BL_02/BL_02.html. Students can use their counts of different species to build their pyramids and then discuss how biodiversity at every level strengthens the pyramid and the vitality of the ecosystem.

Evaluate

Use the *Habitat Evaluation* student handout to evaluate what your students have learned. See the scoring key, below.

Scoring Key for Evaluation

1. Explain how biodiversity benefits an ecosystem.
   Biodiversity increases the resilience and adaptability of an ecosystem by multiplying the interactions between organisms and their interactions with the environment upon which the ecological health of the ecosystem depends.

2. Describe three animal species that you observed in your school garden habitat.

Answers will vary.

3. Describe the role of pollinators in a garden habitat.
   Pollinators play a crucial role in plant reproduction by transferring pollen from the male to the female organs of flowers, which leads to the production of fruits and vegetables.

4. Give examples of a producer, a primary consumer, and a secondary consumer in the ecology of a garden habitat.
   Answers will vary, but students should identify a plant for producer, an herbivore for primary consumer, and an omnivore for secondary consumer.

5. Describe one way to increase biodiversity in a garden habitat.
   Increasing the variety of different plant species in a garden habitat is one way to increase biodiversity among animal species.

Habitat Spotlight: Pollinators

Perhaps the most important species you will observe in your garden are pollinators. Pollinators do the work in the garden, and in any ecosystem, to ensure that your plants are able to produce and reproduce. Without crucial pollinators, your garden and natural systems would not function.

In the following activity, students will learn about the importance of pollinators and use planting activities in the garden to understand how different pollinators are important for different species of plants. This activity can be used at any time in the garden but is ideal for the beginning of the planting season, either when you are installing pollinator plants for the first time in a new garden, or re-planting them for a new season.

Use the pollinator planting guides found at www.pollinator.org to select plants appropriate for pollinators in your area. Click on 'Planting Guides' and enter your zip code to download a pollinator guide specific to your location. Use this to purchase native plants in your area ideal for different types of pollinators. Then use the following activity to turn the planting process into a robust educational opportunity for your students.

Suggested Flow:

1. Explore the important role of pollinators in the garden habitat. Begin by viewing Pollinators – Putting Food on the Table (https://vimeo.com/77811127 - about 3.5 minutes), which dramatizes how food production depends almost completely on pollinators and includes ideas for creating habitats that will attract pollinators. (If appropriate, you may want to show students how pollination leads to the growth of fruits and vegetables with the short Pollination video at https://vimeo.com/6965266 - about 1 minute.)

2. When you are ready to plant your new pollinator plants in the garden (but before you have planted them), organize students into small groups and assign each group a different type of pollinator. Bats, birds, bees, butterflies, moths, wasps, flies, beetles, and lizards all play a role in pollination. Make sure that each pollinator assignment corresponds to the type of pollinator plants you have purchased to install in the garden.

3. Have students use the pollinator guides found at www.pollinator.org to look up their assigned pollinator and identify ideal plant characteristics for their pollinator. For example, the group that has been assigned butterflies as their pollinator will use the guide to learn that butterflies

generally are attracted to brightly colored flowers, like red or orange blooms, and need moist soil and open areas for basking.

4. Once students understand their pollinator and ideal plant characteristics that attract and provide for that pollinator, have them investigate the different types of pollinator plants. Students should pick out the plants they think would best plants provide habitat and food to their pollinator.

5. Re-convene as a class and have each group share what they learned about their pollinator, which plants they chose and why, and how those plants provide for their pollinator. Then, as a class, decide how you will plant the pollinator plants. Should you plant them all together for one pollinator, creating a butterfly bed for example, or should you intersperse them with each other and other plants in the garden. Then have fun planting!

6. **Evaluate:** Use the species census above to collect information about the pollinators in your garden over time. What do the students' observations suggest about pollinator plant preferences? Have their observations confirmed their hypothesis from planting? How do different pollinators respond to different flower colors, shapes, and fragrances? Do certain pollinators seem attracted only to certain plants? Are there unique physical characteristics of certain pollinators and certain plants that could indicate that they have adapted to one another (a process called co-evolution)?

   If there are native and non-native plants in your garden, students can also observe whether these plants attract native and non-native pollinators. (You can download a poster with information about native bees at www.pollinator.org/PDFs/Identifying_Native_Bees_PosterFINAL.pdf.) Have students consider the long-term ecological impact of such specialized pollinator preferences. What could happen if there were no native plants in the garden? How would the overall pollinator population be affected?

Extend: Further Investigations (45 minutes for each activity)

Invasive Species

Take a closer look at the ecological impact of invasive species, especially if students have observed what they think might be an invasive species in your garden. Begin by viewing Invasive Species at www.youtube.com/watch?v=HAY_UsGjyZk, a short video from the Entomological Society of America that illustrates the concept of invasive species in simple terms. Then take students to the USDA National Invasive Species Information Center (www.invasivespeciesinfo.gov) to learn about invasive species that threaten ecosystems in the U.S. Click Animals under "Browse by Subject" for a list of recognized invasive animal species, then click Plants for a similar list of invasive plants. Check the species profile linked to each animal and plant name to determine if there are invasive species in your garden.

a. For more information on invasive species in your area, have students visit the State Resources page at the National Invasive Species Information Center website (www.invasivespeciesinfo.gov/unitedstates/state.shtml). Here they can click on your state for news of suspected invasive species in your region and background on efforts to combat invasive species that have already damaged local ecosystems. Have students work in small groups to research different invasive species, telling the story of how that species arrived in

your state, its impact on habitat biodiversity, and whether or not this impact has affected the economy or humans.

b. For a broader perspective on the problem of invasive species, have students visit The Nature Conservancy's Explore Invasive Species page (https://web.archive.org/web/20160815121144/www.nature.org/ourinitiatives/habitats/forests/explore/explore-invasive-species.xml), which features videos on the impact invasive species are having on forests in the U.S. Students can also learn more at the National Environmental Coalition on Invasive Species website (https://web.archive.org/web/20171005100329/http://www.necis.net/), which offers "Invasive Species Basics" that provides information on U.S. Species Invading Other Countries and Species Invading the United States. Have students use these and other resources they can discover online to report on one especially aggressive invasive species, describing the threat it poses and what measures have been taken to reduce or eliminate the damage it causes.

Pests

Once students have researched invasive species, have a class discussion comparing invasive species to pests and weeds, which are animals and plants that humans do not want in a garden. Do pests and weeds cause long-term harm to the garden ecosystem, as invasive species do? If they are native to the ecosystem, should humans attempt to remove them? Debate how an ecologically informed gardener should respond to pests and weeds. For information about garden pests and how to control them, visit the National Gardening Association's Pest Control Library (garden.org/learn/library/pests). For similar information about weeds, see the Weed Library (garden.org/learn/library/weeds).

Pesticides and Herbicides

As a follow-up to your debate about pests and weeds, have students investigate the potential effects of using pesticides and herbicides in a garden habitat. As mentioned in the Pollinators — Putting Food on the Table video (at 1:44-1:57), pesticides often kill more than pests; they can also kill pollinators and other organisms that may play an important role in the garden's ecology. And herbicides can have similar unintended effects on plant life. In addition, pesticides and herbicides may cause damage to wildlife and humans when inhaled or even on contact, and they can pollute water sources if they enter the watershed through runoff. For a powerful examination of the dangers of pesticides that also shows how far our society has come in its awareness of ecological processes, have students read (or read about) Rachel Carson's *Silent Spring* (1962).

Additional Resources and Further Reading

- Get Wild, Go Native! – check out The Nature Conservancy's native plant gardens initiative.
- Many resources and background information on biodiversity - https://web.archive.org/web/20150320205140/http://www.ecokids.ca/PUB/eco_info/topics/biodiversity/index.cfm
- Everyday ways and actions kids can take to protect and impact biodiversity - https://www.amnh.org/our-research/center-for-biodiversity-conservation/resources-and-publications/what-you-can-do/what-you-can-do
- More on garden insects, both pollinators and pests - https://web.archive.org/web/20160130093157/http://blogs.cornell.edu/horticulture/insects/
- Harmful effects of pesticide use - https://www.panna.org/ (Pesticide Action Network)

- Visit the U.S. Fish and Wildlife Pollinators page (www.fws.gov/pollinators) to download posters that show the wide variety of pollinators found in different parts of the United States.

Habitat Field Report

Conduct a Species Census

In this activity, you will collect data in order to determine the diversity of organisms in your garden and to understand how your garden functions as an ecosystem. You will decide as a class or your teacher will let you know how the census will be organized. Remember, you are scientific observers and need to take care of and not interfere with the organisms and ecosystem you are observing.

(NOTE: If you are allergic to bee stings, make sure to inform your teacher before you head outside.)

PREPARATION

7. You will first conduct your species census in your garden. Then, in order to have an area to compare the garden to, you will also conduct a census in an area outside, but nearby, the garden. Your teacher will help you organize your data collection.

8. Use the tables on the next pages as data collection sheets when you go outside. You will transfer these data to the website back in the classroom. Each part of the table is explained in detail below:

    g. **Organism:** Write in the **common name** of the animal you observe. If you don't know the name, leave this space blank and take a photo of the animal and/or write notes about it in the notes section. You can use a numbered card to hold up in the photo and write the number in the notes section so when you look the photo later, you know which photo corresponds with which notes. After the survey is over, use a field guide to identify the animal.

    h. **Quantity:** Keep a count for each different animal. For example, if you see an earthworm, make one hash mark; then, if you see another earthworm, make another hash mark. Make sure not to count the same animal twice. Some animals, like ants, are hard to count. If you can't count all of the animals, you can estimate and write something like "greater than 50" or "greater than 100".

    i. **Type:** Use the code at the bottom of the chart to identify the type of animal you have observed. Write the corresponding code number on the table.

    j. **Where Observed:** Describe where you observed the animal. Try to include both the general location and exactly where the animal was when you saw it. For example:
        - In the tomato patch, crawling on a stem
        - On a maple tree, sitting on the bark
        - In the squash patch, on the underside of a leaf

    k. **Role:** Some animals play a special role in the garden's ecology. Use the code at the bottom of the chart when you observe an animal that plays one of these roles:

        - Pollinators are animals that spread pollen by flying from flower to flower or by crawling into and out of different flowers. Many pollinators are insects, but many birds, such as hummingbirds, can pollinate plants as well.

        - Decomposers, usually found in or on the soil, are animals that feed on and help break down decayed organic matter. They play an integral role in the health and productivity of the garden. Worms are an example of decomposers in the garden.

- Invasive species are non-native organisms that are usually introduced to an ecosystem or habitat from an external source and can play a harmful role in the ecology of the garden. Invasive species can be plants or animals and may disrupt an ecosystem by dominating a region or particular habitat because of the loss of natural controls (predators or other factors in an ecosystem that keep populations of species in check). When introduced to a new ecosystem or non-native habitat, an invasive species can quickly multiply and dominate, negatively impacting native species, because their population is no longer controlled by predators or other factors.

- Pests also play a harmful role in the garden ecology, but mainly from the gardener's point of view. Aphids and scale insects, for example, which feed on plant sap, can be considered pests when they become so numerous that they weaken or kill a plant. Moles, which burrow through the soil and feed on earthworms, may be considered pests if their burrows disturb plant roots and slow their growth. Gardeners need to be aware of pests like these so they can protect their plants, and you can categorize an animal as a pest if it seems to be damaging a plant.

l. **Notes:** Use this space to describe organisms you need to identify later and to take notes on animal behaviors — both how the animal interacts with the garden environment (for example, flying from flower to flower on a specific plant, hiding under a leaf, perching on a garden sign) and how it interacts with other animals (for example, attacking or eating another animal, running to hide from another animal). Note how you think the animal's behavior fits into the garden ecology and what role the animal plays.

COLLECTING DATA IN THE GARDEN

10. Go to your assigned location in the garden. Your teacher will have explained the method that you will use to collect data (e.g. transect, quadrat, square foot). Make sure you bring the necessary measuring tools.

11. Do not interfere with the animals you observe. No poking, teasing, grabbing, or swatting. Show care for the garden and its inhabitants and try to have the least possible impact on what you are observing so as not to interfere with the data.

12. You will have 10-minutes to collect data in the garden habitat.

13. Keep a detailed and complete record of what you observe – the more consistent and detailed you are in the data you collect, the more scientifically accurate and meaningful the information. If you collect data in a consistent way, you can then compare these data across time periods and to other data you have collected about your garden. Record data on the "Garden" data sheet.

14. After each observation period, you can use the field guides to look up any organisms you couldn't identify.

COLLECTING DATA OUTSIDE OF THE GARDEN

1. To assess biodiversity outside of the garden, conduct a test species census using the same method that you used in the garden, in another natural area on the school campus. This location could be a lawn or bed of shrubbery where the plant life is less varied.

2. You will have 10 minutes to conduct this survey. Record data on the "Other Location" data sheet.

GARDEN: Habitat Data Collection Sheet

Use this sheet to record your observations of animals in the garden.

Organism – Common Name	Qty	Organism Type	Where Observed	Role	Notes

Organism Type Code:

1. Arachnid
2. Bee
3. Beetle
4. Butterfly
5. Dragonfly
5. Grasshopper
6. Moth
7. Slug
8. Worm
9. Other bug or insect
11. Amphibian
12. Reptile
13. Bird
14. Mammal
15. Other organism

Role Code:

a. Pollinator
b. Decomposer
c. Invasive species
d. Pest

OTHER LOCATION: Habitat Data Collection Sheet

Use this sheet to record your observations of animals outside, but nearby, the garden.

Organism – Common Name	Qty	Organism Type	Where Observed	Role	Notes

Organism Type Code:

1. Arachnid
2. Bee
3. Beetle
4. Butterfly
5. Dragonfly
6. Grasshopper
7. Moth
8. Slug
9. Worm
10. Other bug or insect
11. Amphibian
12. Reptile
13. Bird
14. Mammal
15. Other organism

Role Code:

a. Pollinator
b. Decomposer
c. Invasive species
d. Pest

Habitat Data Analysis

In your data collection group, discuss the following questions and prepare a summary to share with the class.

1. Identify the species that are observed most frequently in the garden. Suggest reasons why you might have seen these species so repeatedly.

2. Use your observation notes to investigate the relationship between animals and plants in the garden.

    - Are certain types of animals almost always seen on or near certain types of plants?

    - Are some species most frequently seen on or near certain parts of plants (leaf, stem, root, flower, etc.)?

    - Are there animals that you observed only when plants are flowering or only when they are have produced a fruit or vegetable?

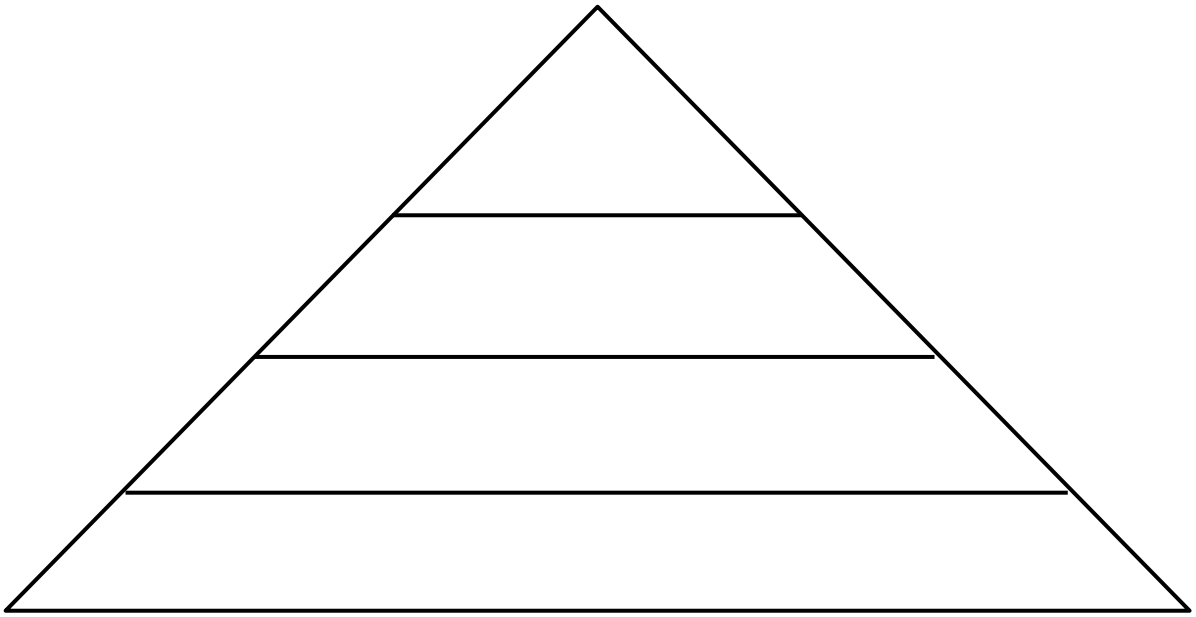
    - What other patterns did you notice? How might these patterns be related to a species' need to eat, reproduce, and/or protect itself from predators?

3. Complete the environmental "zones" chart below. Use your observation notes to determine whether certain species are found in a specific zone and list them under the appropriate heading in the table.

Environmental Zone Species Comparison		
Shady	vs.	Sunny
Moist	vs.	Dry
Elevated areas (tree leaves, branches)	vs.	Lower areas (soil, ground)

4. Compare the number of different species you observed at the second, non-garden site with the numbers you have observed in the garden. What did you notice? Use data to support your answer.

5. Use your data to create an ecological pyramid depicting the animal and plant life in the garden habitat. An ecological pyramid diagrams energy transfer through an ecosystem, from the producers (plants) at the bottom of the pyramid up through primary consumers (herbivores), secondary consumers (omnivores), and tertiary consumers (carnivores), showing how the amount of available energy and (usually) the number of organisms decreases at each stage.



Habitat Evaluation

Using data the whole class has collected, answer the questions below.

1. Explain how biodiversity benefits an ecosystem.

2. Describe three animal species that you observed in your school garden habitat.

3. Describe the role of pollinators in a garden habitat.

4. Give examples of a producer, a primary consumer, and a secondary consumer in the ecology of a garden habitat.

5. Describe one way to increase biodiversity in a garden habitat.