10. Modeling an Ecosystem

Driving Questions

An ecosystem is a community of species that interacts with one another and the physical and chemical surroundings. Ecosystems can be both large and small. Measuring and monitoring an ecosystem allows us to understand what an ecosystem is, and how it can be protected.

- What makes up an ecosystem?
- How does human-introduced pollution affect an ecosystem?

Background

The term "ecosystem," coined by British botanist Roy Clapham in 1930, refers to any system of living, or biotic, organisms that functions with non-living, or abiotic, chemical or physical factors in the environment. The central idea behind the ecosystem is that all biotic organisms are continually engaged in a relationship with other biotic and abiotic components. The ecosystem develops as a product of each organism's relationship with every other organism. Ecosystems are highly sensitive to change, and introducing new elements can have dramatic effects on both the biotic and abiotic organisms present.

An environment does not have to be large or exotic to be considered an ecosystem. A system as small as a single plant and soil, or one as large as a rainforest, can be considered an ecosystem. Any ecosystem is governed by the sum of individual responses from all organisms in the ecosystem. Prominent ecosystems include the Amazon Rainforest, the Great Barrier Reef, and Yellowstone Park.

In this activity, you will be asked to design 3 individual chambers, which will be interlinked. There are many types of environments you could attempt to emulate including aquatic, decomposition, and terrestrial. You can add living organisms to your design, including plants, fish, and insects and you can use different soil types and organic material in the different chambers.

It is important to first brainstorm and then clearly identify what to put into each terrarium prior to setting up the activity. Things they should keep in mind include: 1) the type of water to add (for example, distilled, tap, or from a local water source), 2) the types of living organisms to add to the ecosystem and how they will be obtained, 3) soil sources and how the soil will be obtained, and 4) the parameters they want to monitor.

Materials and Equipment

For each student or group:

- Oxygen gas sensor [1]
- Carbon dioxide sensor[1]
- Temperature sensor[1]
- pH sensor [1]
- Conductivity sensor[1]
- Weather sensor[1]
- Water quality colorimeter[1] and sample vials (nitrate and ammonia recommended)
- EcoZone™ System
- Different types of living organisms
- Strong incandescent or full-spectrum fluorescent
- light source
- Plant seeds or seedlings, or moss
- Water, dechlorinated (quantity depends on design)
- Pollution source
- Compost or soil

[1]These are a sample of the sensors for this student-designed activity. Not all are needed for a successful experiment.

Safety

Add these important safety precautions to your normal laboratory procedures:

- Consult the manufacturer's material safety data sheets (MSDS) for instructions on handling, storage, and disposing of hydrochloric acid. (You can find these on the Internet.) Keep these instructions available in case of accidents.
- Do not touch the hydrochloric acid (HCl). Handle the pipet with HCl with extreme care.
- After completing the lab, wash your hands.
- Wear safety glasses and lab coats or aprons.

Procedure

After you complete a step (or answer a question), place a check mark in the box (☐) next to that step.

There are three chambers to the EcoZone™ System. Each of these chambers can be filled with any abiotic material or living organism you can bring in from home or that your teacher can provide for you.

Discuss with your team the important factors in building an ecosystem. Remember that adding live organisms to these zones means you are responsible for providing them with all of the necessities of life.

Part 1 – Design your experiment

1. ☐ Write a brief outline of the procedure you will use to set up the EcoZone chambers and collect data. Include the following information:
   a. What are your principle design considerations (what is the goal of your experiment)?

b. What are the independent variables? What are the dependent variables? What are you keeping the same? What parameters will you measure?

c. What are the biotic and abiotic components you are adding to each chamber?

Note: Part of your experiment should determine the effect of the addition of a pollutant.

2. ☐ Draw a diagram of the experimental setup you will use. Be sure to label the biotic and abiotic materials in each chamber and the sensor or sensors that will be in each chamber.

3. ☐ What roles will you and your research team play in creating, monitoring, and analyzing the EcoZone system?

4. ☐ Will the system remain closed? Will you open the system periodically to water plants or feed organisms? How will you account for your influence on the system if it is opened?

Part 2 – Set up your experiment and collect data

5. ☐ Calibrate sensors that require calibration, according to the instructions provided with the sensor.

Note: Keep the file open that contains this calibration information. The sensor calibration remains with the file that was open when you performed the calibration.

6. ☐ Why is it necessary to calibrate sensors?

7. ☐ Add the materials to each chamber.

8. ☐ Seal the chambers so they are airtight.

Hint: One way to be sure that the terrarium is airtight is to exhale several times into the empty chamber to raise the CO_2 level of the air in the terrarium relative to the room air. Then seal the terrarium and monitor the CO_2 level for several minutes with a carbon dioxide gas sensor. After the reading stabilizes, the level should not drop. If it does, you probably have a leak. Once you have learned how to make the terrarium airtight, use this procedure in your investigations.

9. ☐ Insert the sensors and begin collecting data. Collect data for at least 24 hours. Your teacher may want you to monitor data for an extended period of time.

Part 3 – Add a pollutant and monitor data

10. ☐ After a minimum of 24 hours of data collection, add the pollutant provided by your teacher to at least one of the chambers.

11. ☐ Why do you need to wait 24 hours before adding a variable?

12. ☐ What type of pollutant did you add to your system? What chamber did you add the pollutant to?

13. ☐ What effect do you think the pollution will have on the measurements being recorded in each chamber?

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14. ☐ Why is the substance you added to the chamber considered a pollutant?

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Data Analysis

1. ☐ Record any changes made to your experimental design, or any time the system was opened to the external environment

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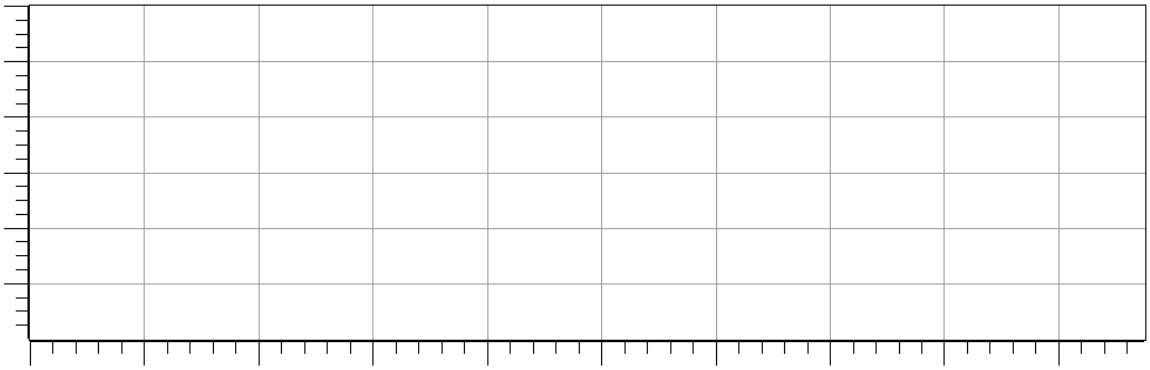
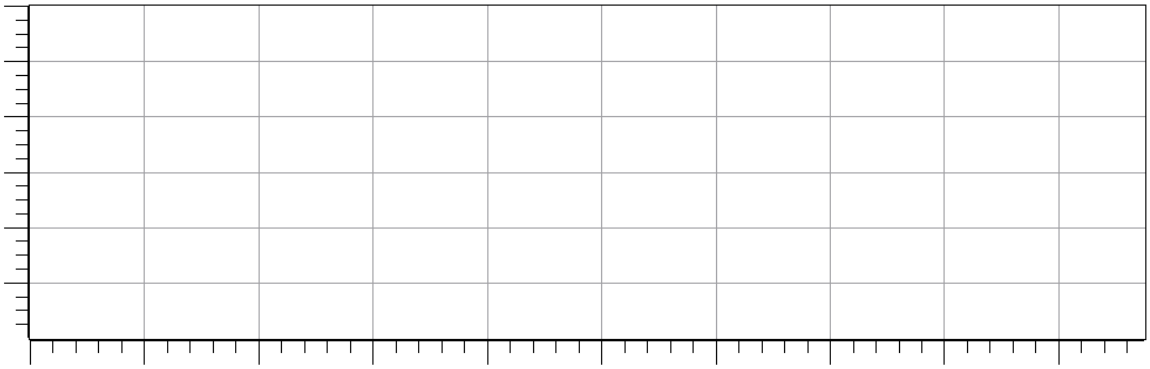
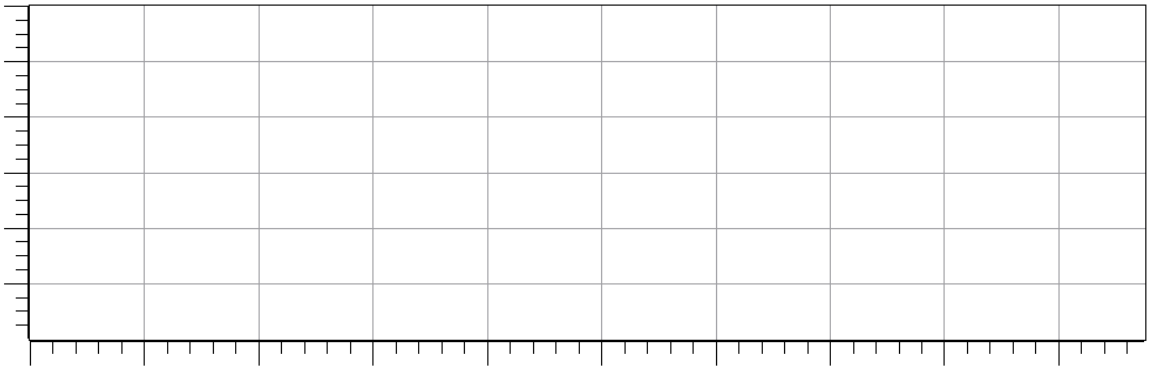
2. ☐ Create a table below that displays data you feel is relevant for others to know about the experiment *before* the pollutant was added. Below the table, add comments regarding the conditions in the chambers throughout the course of the experiment.

3. ☐ Create a table below that displays data you feel is relevant for others to know about the experiment *after* the pollutant was added.

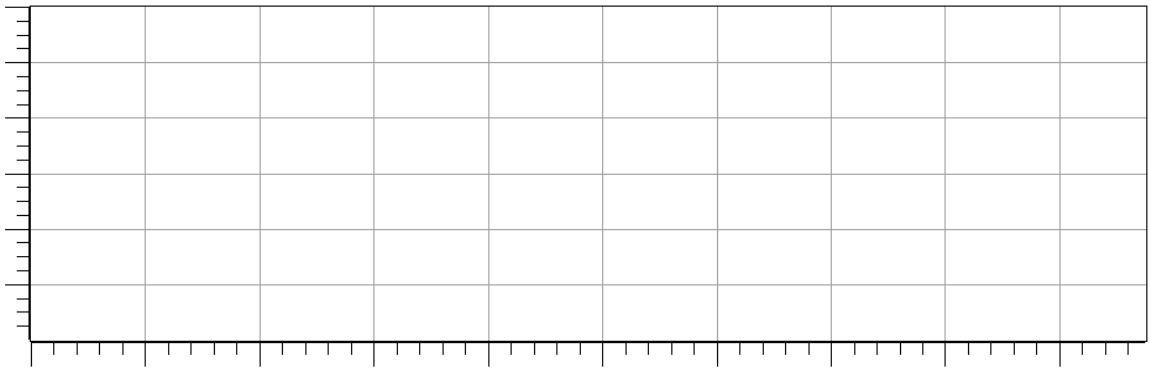
4. ☐ Graph the set of data that changed the most over the period of data collection prior to adding the pollutant.

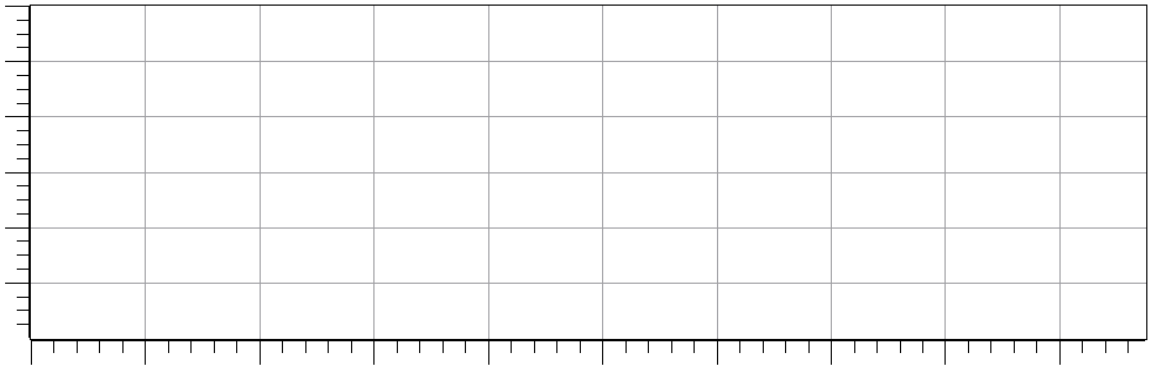


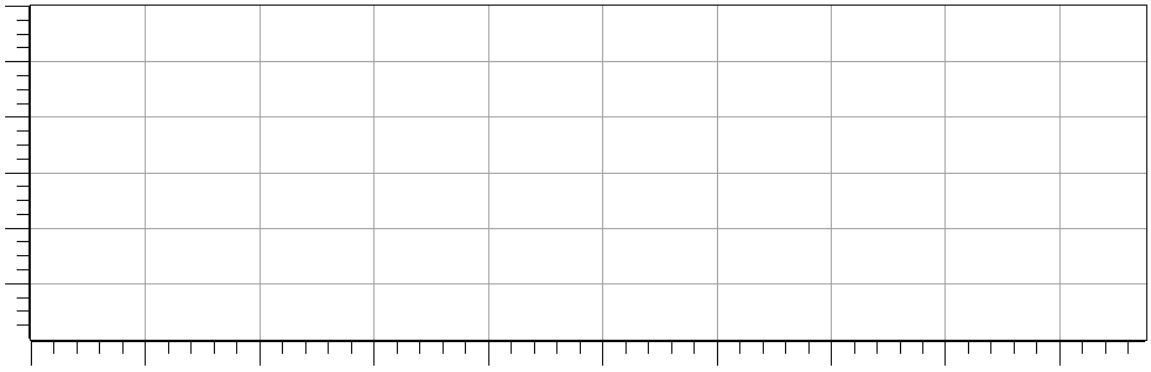




5. ☐ Graph the set of data that changed the most after the pollutant was added.







Analysis Questions

1. **Describe any significant changes you observed in the chambers during the course of the experiment**

2. **What parameter changed the most prior to adding the pollutant? Explain why you think that factor changed the most.**

3. **What parameter changed the most after the pollutant was added? What is the significance of this?**

4. **The pollutant may, or may not, have affected your chambers.**

   a. If there was a significant change, what further tests would you want to conduct to determine if the pollutant was the sole cause of the change?

   b. If there was no significant change, what further tests would you want to conduct to determine if the concentration of the pollutant is important?

Synthesis Questions

Use available resources to help you answer the following questions.

1. **Design an additional study to determine how a different pollutant could affect the ecosystem. What pollutant would you use? What changes would you expect to see? How would you measure those changes?**

2. **Consider the type of pollutant you added to your system. Where could you find a similar pollution source in a natural environment?**

3. **Agricultural farming typically requires fertilizer to be added to the soil to ensure high quality crops. Rain and runoff wash excess fertilizers into local waterways. Based on your experience, what type of positive and negative consequences could result from this runoff?**

Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. **Which of the following are considered consumers?**

   A. Green plants
   B. Photosynthetic protists
   C. Parasites associated with plants and animals
   D. Chemosynthetic bacteria

2. **Bacteria found in the soil are important in which of the following cycles?**

   A. The water cycle
   B. The carbon cycle
   C. The nitrogen cycle
   D. The phosphorus cycle
   E. All of the above

3. **The transitional zone found between two adjacent ecosystems is called the:**

   A. Community
   B. Biome
   C. Ecotone
   D. Optimum
   E. Zone of tolerance

4. **What types of organisms are found in the first trophic level in an ecosystem ?**

   A. All heterotrophs
   B. Carnivores
   C. Herbivores
   D. All autotrophs
   E. A and B

5. **Which of the following is not a natural process that occurs in ecosystems?**

   A. Production of pollutants
   B. Erosion control and topsoil building
   C. The control of the earth's climate
   D. Maintaining of biogeochemical cycles
   E. Regulation of global carbon dioxide

6. **Ecosystems are comprised of which of the following components:**

   A. Living organisms only
   B. Non-living structures in the environment only
   C. Both biotic and abiotic factors
   D. Flora and fauna
   E. Fauna only