



HEADWATERS
SCIENCE INSTITUTE

EXPLORING ECOSYSTEMS THROUGH SAMPLING

INVESTIGATING HOW ECOLOGISTS USE QUADRATS TO
SAMPLE & STUDY POPULATIONS WITHIN AN ECOSYSTEM

Student Investigation

In this lesson, students will investigate how ecologists study populations and biodiversity within an ecosystem. Students will use a grid and cookie model to practice quadrat sampling, a method scientists use to estimate the abundance and distribution of organisms within a larger area. By examining a smaller section of the model ecosystem, students will collect data on different species and then share their results with the class to create a more complete snapshot of the larger ecosystem.

As they collect and analyze their data, students will identify patterns in species abundance and distribution and explore how combining multiple samples can provide a more accurate picture of biodiversity. They will consider how sample size, sampling location, and bias can influence their results. Through this investigation, students will build skills in ecological sampling, data collection, quantitative analysis, identifying patterns, and using evidence to draw conclusions about populations and ecosystem health.



NGSS STANDARDS

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 explanation that predicts patterns of interactions among organisms across multiple ecosystems.

HS-LS2-1: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

This activity incorporates Science and Engineering Practices (SEPs) through developing and using models, collecting and analyzing data, identifying patterns, and using evidence to explain how predator-prey interactions and resource availability affect populations and ecosystems.

AP Topics

- Unit 2: The Living World - 2.1 Introduction to Biodiversity

Educator Instructions: Leading the Investigation

Introduction

At Headwaters Science Institute, students don't just learn about science, they become scientists. Through student-driven research, students make observations, ask questions, collect evidence, and use data to better understand the world around them. This investigation is designed to help students experience the scientific process firsthand while exploring how scientists use sampling methods to study biodiversity, identify patterns in populations, and develop a more complete understanding of ecosystem health.

After learning about biodiversity, tools of Ecology, and bias, students will use a mock quadrat and cookie to investigate biodiversity within a model ecosystem. They will collect and record data from their sample, then share their results with the class to create a larger dataset representing the ecosystem.

By comparing their individual results with the combined class data, students will identify patterns in species abundance and distribution and explore how multiple samples can provide a more complete picture of an ecosystem. They will consider how sampling location, sample size, and bias can influence ecological data and the conclusions scientists draw.

Introducing the Lab:

Students will begin by considering the driving question and using it to guide their investigation. After introducing the lab by reviewing the driving question and reminding students that scientists often study ecosystems that are too large to examine in their entirety. Explain that they will use a cookie and mock quadrat as a model ecosystem.

Have students place their cookie within the mock quadrat and identify the different species represented by each M&M color. Students should count the total number of each species and record their observations. Before beginning the hands-on investigation, ask students to predict whether their single sample will accurately represent the biodiversity of the entire mock ecosystem and what additional data might help them get a better picture.

Materials

- M&M or multi-colored cookies
 - Red = Predator Species
 - Blue = Prey Species
 - Yellow = Insect
 - Green = Plants



Biodiversity: Studying Ecosystems, Sampling Populations, and Avoiding Bias

Biodiversity helps scientists understand how ecosystems function and how organisms are distributed. Because ecosystems can span large areas, scientists use tools such as quadrats and transects to sample populations and identify patterns. Careful sampling is also important to avoid bias and ensure data accurately represents the ecosystem. By exploring biodiversity, sampling tools, and ways to reduce bias, students will learn how ecologists collect reliable data to better understand ecosystems.



BIODIVERSITY

Biodiversity describes the variety of living organisms within an ecosystem, including the diversity of species and differences among organisms. It is important because each species plays a role in ecosystem processes such as nutrient cycling, pollination, food webs, and habitat stability. More diverse ecosystems are often better able to withstand and recover from environmental changes and disturbances because they have multiple species contributing to ecosystem functions. Understanding biodiversity helps scientists assess ecosystem health, identify patterns in species distribution, and understand how changes in one population can affect the broader ecosystem.



TOOLS FOR EXPLORING BIODIVERSITY

Scientists use a variety of tools and sampling methods to study biodiversity and understand how organisms are distributed within an ecosystem. Quadrats are small, defined areas used to count and record organisms within a larger habitat, while transects are lines or paths used to observe how organisms change across an area or environmental gradient. Scientists toss or place quadrats at random to avoid bias and ensure that their samples are not chosen based on where organisms are easiest or most interesting to find. Scientists also use field guides, cameras, measuring tools, and other equipment to identify and document organisms. These tools allow scientists to collect consistent data, identify patterns, and make estimates about populations and biodiversity across larger ecosystems.



SAMPLING WITHOUT BIAS

Bias occurs when the way data is collected consistently favors certain organisms, locations, or conditions, causing the results to be less representative of the larger ecosystem. For example, if scientists only collect data from areas that are easy to access or where they expect to find certain organisms, their results may not accurately reflect the ecosystem as a whole. Scientists can reduce bias by using consistent methods, randomly selecting sampling locations, collecting multiple samples, and making sure their sampling covers a variety of conditions within the ecosystem. These strategies help scientists capture natural variation and avoid drawing conclusions from a single area or observation. By reducing bias, scientists can collect more representative data, identify reliable patterns, and make stronger conclusions about biodiversity, population patterns, and ecosystem health.



Student Investigation

Investigating Biodiversity

How can scientists use a small sample to understand the biodiversity of a larger ecosystem?

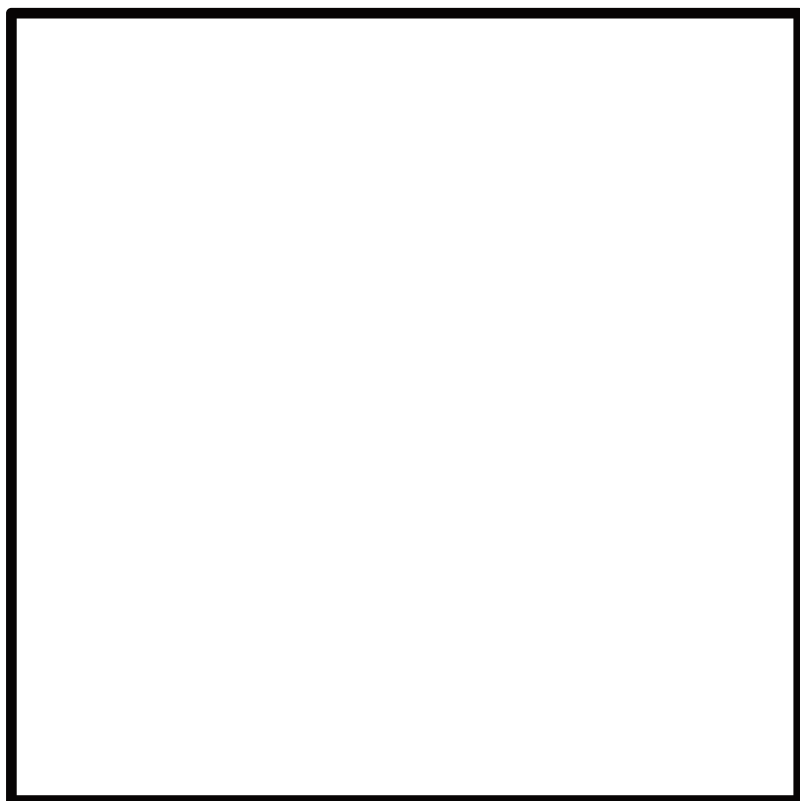
Ecologists often study ecosystems that are too large or complex to observe all at once. To better understand the organisms living in an ecosystem, scientists use sampling tools such as quadrats to examine smaller sections of a larger area.

In this investigation, you will use an M&M cookie as a model ecosystem. Each M&M color represents a different type of organism:

- Red = Predator Species
- Blue = Prey Species
- Yellow = Insect
- Green = Plant

Place your cookie in the Quadrat and count the total number of each species on your cookie, record your results in the chart to the right. As you collect data, look for patterns in the abundance and distribution of the different organisms.

Your goal is to explore how scientists can use small samples to better understand the biodiversity of a larger ecosystem and investigate how the location and size of a sample can influence the conclusions scientists draw.



Place your Cookie in this mock
Quadrat

Species Type	Total Count
Predator	
Prey	
Insect	
Plant	



Student Investigation

Compare Your Results

Your sample represents just one small part of the larger mock ecosystem. To develop a better understanding of the ecosystem's overall biodiversity, compare your results with those of the rest of the class.

Ask each group to share the number of each species they counted. Add the results from every group together to determine the total number of each species represented across the entire mock ecosystem.

Species Type	Total Count
Predator	
Prey	
Insect	
Plant	

Discussion Questions

- 1.How did combining data from multiple cookies give you a better understanding of the overall biodiversity of the ecosystem?
2. More diverse ecosystems are often healthier and better able to withstand disturbances. Based on the data you collected, make a conclusion about the overall health of your ecosystem. Use evidence from the number and variety of predators, prey, insects, and plants to support your conclusion.
3. How could bias affect the data scientists collect when studying an ecosystem? What could scientists do to reduce bias during sampling?