



INVESTIGATING TROPHIC CASCADES

INVESTIGATING HOW PREDATOR-PREY INTERACTIONS SHAPE POPULATIONS AND TROPHIC CASCADES

Student Investigation

In this lesson, students will investigate how predator and prey populations interact within an ecosystem. Students will model the relationship between wolves and elk through a predator-prey simulation, with elk representing primary consumers and wolves representing secondary consumers. They will collect data on population size, survival, and resource availability across multiple rounds to observe how changes in one population can affect another. As they collect and analyze their data, students will identify patterns in predator-prey population dynamics and explore how factors such as food availability, predation, and habitat can influence population size. They will use their results to investigate how changes at one trophic level can produce effects that extend throughout an ecosystem, introducing the concept of trophic cascades. Through this investigation, students will build skills in modeling, data collection, quantitative analysis, identifying patterns, and using evidence to explain interactions within food webs.

[Watch our talk with Angie Ruiz](#) to introduce this lesson.



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.

MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

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

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.

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

- APES Unit 8: Topic 8.5: Community Ecology

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 changes in predator and prey populations can affect other organisms and resources throughout an ecosystem.

Students will begin by considering the driving question and using it to guide their investigation. After learning about trophic levels, predator-prey interactions, and resource availability, students will model a wolf-elk ecosystem and track changes in population size and survival across multiple rounds. By analyzing their data and identifying patterns, students will develop an evidence-based explanation for how changes in one trophic level can affect other populations and contribute to trophic cascades.

Introducing the Lab: Each round takes about 5 minutes, providing time to discuss observations and population changes. Use the simulation to introduce predator-prey relationships and how changes in one population can affect others in an ecosystem.

- Divide students into Wolves and Elk, with approximately 1 Wolf for every 4 Elk.
- Establish a playing area with a Permanent Refuge for Elk and several Temporary Refuges. Spread food tokens throughout the area to represent available vegetation.
- Explain that Elk are primary consumers and Wolves are secondary consumers. Ask students to predict how the populations will change as they interact.
- Have Wolves spread out across the playing field before each round.
- Explain that each round represents a period of time, such as one year.
- Run 2–3 baseline rounds. During each 5-minute round, Elk must collect and return 3 food tokens to the Permanent Refuge to survive, while Wolves must successfully tag at least 1 Elk to survive.
- At the end of each round, record the number of surviving Wolves and Elk and the amount of vegetation remaining.

Then introduce the following ecosystem changes:

Scenario 1: Wolf Decline- Remove half of the Wolves.

Scenario 2: Increased Wolf Population -Add additional Wolves.

Scenario 3: Drought - Remove 50% of the vegetation tokens.

Scenario 4: Habitat Loss- Remove several Temporary Refuges.

- **Scenario 5:** Wolf Reintroduction- Return the Wolf population to its original size after a period of low Wolf abundance

Materials

- Food tokens representing available vegetation
- Chalk or cones for temporary shelters
- Cones to mark boundaries
- Data collection sheets
- Timer



Population Dynamics: Causes, Patterns, and Impacts on Ecosystems

Predator-prey interactions are an important part of healthy ecosystems. Wolves help regulate elk populations through predation, while elk influence vegetation through grazing. Because these organisms are connected through a food web, changes in one population can affect other organisms and resources throughout the ecosystem. By investigating wolf and elk populations, students can better understand trophic levels, population dynamics, and trophic cascades and how changes to predators can ultimately influence entire ecosystems.



POPULATION DYNAMICS

Population dynamics describes how and why populations change over time. Factors such as resource availability, predation, competition, disease, and environmental conditions can cause populations to grow, decline, or fluctuate. Populations are also influenced by birth rates, death rates, immigration, and emigration, which determine how population size changes over time. In an ecosystem, these changes are interconnected, meaning a change in one population can affect other organisms, resources, and habitats. Scientists identify patterns, predict how populations may respond to environmental changes and disturbances, and better understand how ecosystems maintain or lose stability.



TROPHIC LEVELS AND ECOSYSTEMS

Food webs show how organisms are connected through feeding relationships and how energy moves through an ecosystem. Trophic levels describe an organism's position in that food web, from producers to primary, secondary, and higher-level consumers. Each organism plays a role in maintaining the flow of energy and balance within an ecosystem, moving from primary to secondary to higher level consumers. Removing or changing one organism can affect populations throughout the food web and disrupt the entire ecosystem. These effects can extend beyond direct predator-prey relationships, influencing population sizes, resource availability, and habitat conditions.



TROPHIC CASCADES

Trophic cascades occur when changes to one trophic level trigger a chain of effects throughout an ecosystem. For example, removing a top predator can cause prey populations to increase, leading to greater pressure on plants and other resources. These changes can affect species abundance, habitat structure, biodiversity, and ecosystem health. Trophic cascades demonstrate how organisms are interconnected and how a change to one species can create direct and indirect effects across multiple trophic levels. Understanding these interactions helps scientists predict how ecosystems may respond to changes such as predator loss, species reintroduction, habitat change, or human activity.



Student Investigation

Trophic Cascade Challenge

In this activity, you will model how wolves, elk, and vegetation interact within an ecosystem. You will collect data over several rounds and then change different parts of the ecosystem to investigate how those changes affect populations across multiple trophic levels.

Part 1: Establish a Baseline

1. Your instructor will divide the class into Wolves and Elk.
2. Identify the Permanent Refuge and Temporary Refuges. ***These areas provide shelter for Elk and cannot be entered by Wolves.***
3. Food tokens represent vegetation available to the Elk.
4. Remember the trophic levels you are modeling: Vegetation → Elk → Wolves

Predict how elk and wolf populations will change as they interact.

 Elk Rules	 Wolf Rules
• Your goal is to obtain enough food to survive the round. • You must successfully return 3 food tokens to the Permanent Refuge. • You may carry only one food token at a time. • You may enter a Temporary Refuge or the Permanent Refuge to avoid Wolves. • Wolves cannot tag you while you are inside a refuge. • You may remain inside a refuge for as long as you choose. • If you are tagged by a Wolf, you are considered preyed upon and removed from the population for the remainder of the round. • If you do not return 3 food tokens to the Permanent Refuge before the round ends, you do not survive the round. • Once you have returned 3 food tokens, remain at the Permanent Refuge until the round ends.	• Your goal is to successfully capture Elk. • You must successfully tag at least 1 Elk during the round to survive. • Elk cannot be tagged while they are inside a refuge. • Once you tag an Elk, the Elk leaves the playing field and reports to the designated data collection area. • Wolves may continue hunting after capturing one Elk.

Round	Starting Elk	Starting Wolves	Elk Surviving	Wolfs Surviving
1				
2				
3				



Student Investigation

Trophic Cascade Challenge

Scenario 1: Wolf Decline

Predict: What will happen to the Elk population? What might happen to vegetation?

Scenario 2: Increased Wolf Population

Predict: How will this impact wolf, elk, and vegetation populations?

Scenario 3: Drought

Predict: How might a decrease in primary productivity affect organisms at higher trophic levels?

Scenario 4: Habitat Loss

Predict: How does habitat structure influence the relationship between predators and prey?

Scenario 5: Reintroduction

Predict: What might happen to the Elk population and vegetation over several subsequent rounds.

Scenario	Starting Elk	Starting Wolves	Elk Surviving	Wolves Surviving
Wolf Decline				
Increased Wolf Population				
Drought				
Habitat Loss				
Reintroduction				

Discussion Questions

1. Which scenario created the biggest changes to wolf, elk, and vegetation populations throughout the ecosystem? Use evidence from the investigation to support your answer.
2. How does this simulation demonstrate a trophic cascade, or a change in one part of an ecosystem that causes effects throughout other trophic levels?