



MOUNTAIN PINE BARK BEETLE INVASION

INVESTIGATING HOW SPECIES INTERACTIONS IMPACT FOREST ECOSYSTEMS

Student Investigation

In this lesson, students will investigate the impacts of a Mountain Pine Bark Beetle invasion by modeling how populations change within a mock forest ecosystem. Students will simulate beetle population dynamics by rolling dice to determine whether beetles reproduce, die off, or if resistant trees enter the ecosystem and influence the survival of the beetle population. As they analyze the results of each simulation, students will observe how interactions between species and environmental changes can influence population growth and ecosystem stability.

They will interpret their observations to better understand the challenges invasive species can create and how natural adaptations can affect the balance of an ecosystem. Through this investigation, students will build skills in scientific modeling, making observations, and analyzing patterns while exploring how ecosystems respond to biological changes.



NGSS STANDARDS

MS-LS4-4: Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors.

HS-LS4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

This activity incorporates Science and Engineering Practices (SEPs) through developing and using models, making observations, analyzing patterns, and using evidence to explain how ecosystem changes influence populations.

AP Topics

- APES: 2.1 Population Ecology and 2.2 Growth and Resource Availability
- AP Biology: Unit 8.3 Population Ecology, 8.5 Community Ecology, and 8.7 Disruptions to Ecosystems

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 an environmental issue that affects every community: air quality.

Students will begin by considering the driving question and using it to guide their investigation. After learning about natural selection, genetic variation, and how environmental pressures can influence populations, students will explore the beetle population simulation to investigate how traits affect survival over time. By analyzing changes in the beetle population and the evidence from their simulation data, students will develop an evidence-based explanation for how environmental conditions can drive changes in populations.

Teacher Tips: Have students compare their results with another group to create a larger shared data set. Analyzing data from multiple simulations can help students identify patterns, evaluate how environmental factors influence populations, and develop stronger evidence-based explanations about natural selection. After completing the simulation, students will analyze the changes in the beetle population and evaluate how environmental conditions affected survival.

As they compare results and look for patterns, encourage students to revisit the driving question throughout the investigation.

Students should use their simulation data to support their claims, consider how environmental pressures influence populations, and explain how natural selection can shape populations over time.

Remind students that scientific investigations often lead to new questions, and that using evidence to explain how and why populations change is just as important as identifying the outcome.

Modification: Hands-On Beetle Population Simulation

For a more hands-on investigation, students can use physical manipulatives to represent beetles and environmental conditions while keeping the same simulation setup. Provide students with different colored beads, paper clips, tokens, or other small objects to represent beetles in a population. Students can use different colored items to represent beetles, non-resistant trees, and resistant trees, allowing them to model how environmental conditions impact beetle survival.

Students can manipulate the materials through each round of the simulation, track changes in the population, and record their observations and data. Using physical models helps students visualize interactions between beetles and their environment, identify patterns, and develop evidence-based explanations about how environmental pressures can influence populations over time.



Invasive Species: Impacts, Adaptations, and Ecosystem Resilience

Invasive species can disrupt ecosystems by changing population sizes, competing with native species, and altering the balance of interactions within an environment. Genetic variation within populations allows some organisms to have traits that help them survive environmental challenges, such as disease, climate changes, or new predators. By studying how populations respond to these changes, scientists can better understand natural selection, adaptation, and how ecosystems change over time.



NATURAL SELECTION

Natural selection occurs when environmental pressures influence which traits help organisms survive and reproduce within a population. Factors such as changes in climate, disease, competition, and invasive species can create challenges that some individuals are better adapted to handle than others. Over time, organisms with beneficial inherited traits are more likely to survive and pass those traits to future generations, causing populations to change. By studying natural selection, scientists can better understand how genetic variation, adaptation, and ecosystem changes shape the survival of species.



INVASIVE SPECIES IMPACTS

Invasive species are organisms that are introduced to an environment where they are not naturally found and can cause harm to native species and ecosystems. These species may spread quickly because they often have few natural predators, diseases, or competitors in their new environment. As invasive species increase in number, they can disrupt food webs, compete for resources, and change the balance of ecosystems. By studying invasive species, scientists investigate how organisms interact with their environments and develop strategies to protect biodiversity and maintain healthy ecosystems.



ECOSYSTEM DYNAMICS

Genetic variation is the natural difference in traits among individuals within a population. These differences can influence how organisms respond to environmental challenges, such as changes in climate, disease, competition, or invasive species. When some individuals have traits that provide an advantage, they may be more likely to survive and reproduce, passing those traits on to future generations. By studying genetic variation, scientists can better understand how populations adapt, how species evolve, and how biodiversity influences the stability and resilience of ecosystems.



Student Investigation

In this investigation, you will model how a Mountain Pine Bark Beetle outbreak affects a forest by tracking changes in the populations of bark beetles, non-resistant pine trees, and resistant pine trees over time. As you collect, graph, and analyze your data, you will investigate how invasive species impact ecosystems, explore how genetic variation influences survival, and better understand how scientists use models to study population dynamics, natural selection, and ecosystem change.

How does genetic variation in a forest influence the survival of trees during a bark beetle outbreak?

Hypothesis:

Mountain Pine Bark Beetle Invasion:

1. Complete each round of the simulation by following the provided simulation rules.
2. At the beginning of the investigation and after each round:
3. Roll the die.
4. Update the bark beetle, non-resistant tree, and resistant tree populations based on the simulation rules.
5. Record the new populations in your data table.

Rounds 1–5: Beetle Outbreak

The forest is dominated by non-resistant trees, making it easy for bark beetles to spread.

Dice Roll Rules:

1: No change.

2–6: Bark beetles reproduce. Add 10 beetles. Remove 5 non-resistant trees that have been killed by the expanding beetle population.

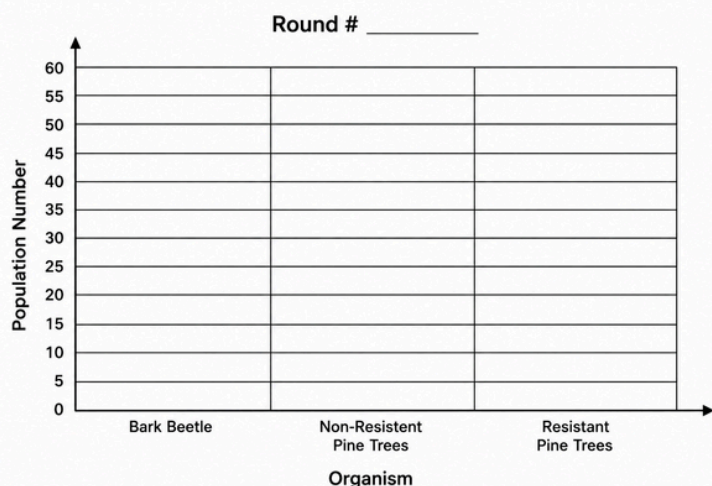
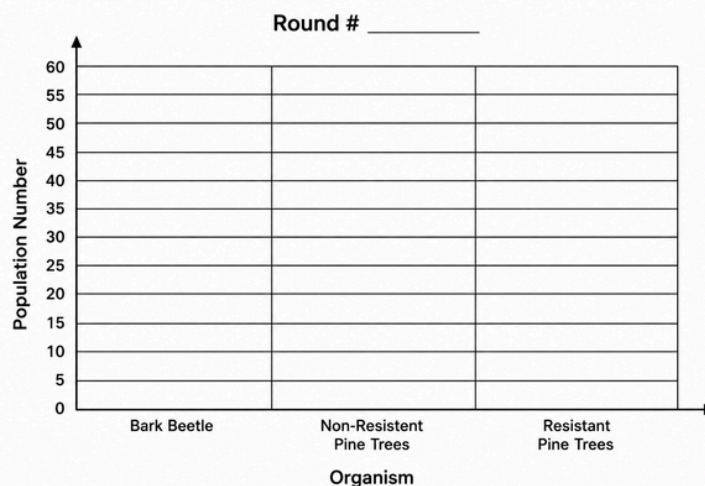
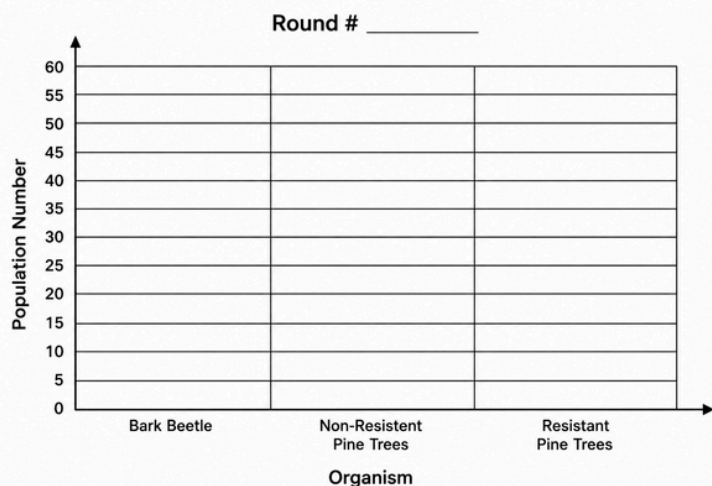
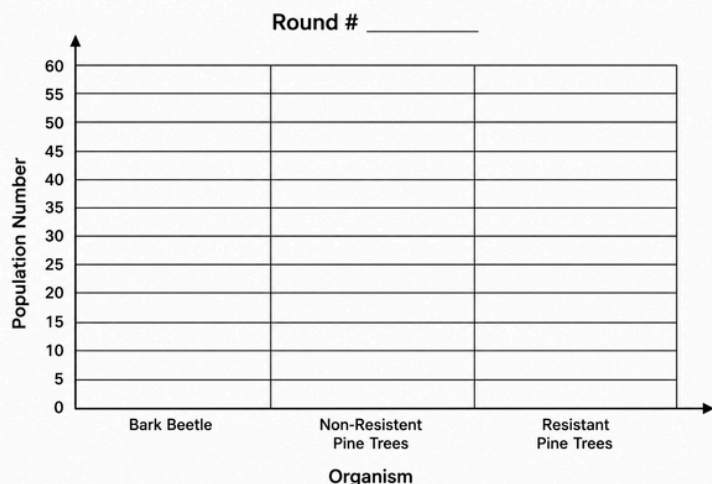
Starting Population: 25 Bark Beetles, 40 Non-Resistant Pine Trees, 10 Resistant Pine Trees

	Starting Population	Round 1	Round 2	Round 3	Round 4	Round 5
Pine Bark Beetles	25					
Non-Resistant Pine Trees	40					
Resistant Pine Trees	10					



Student Investigation

Use the data you collected during each round to create a bar graph showing the changing populations throughout the investigation. Use the same three colors for bark beetles, non-resistant trees, and resistant trees each time, then compare your graphs to identify patterns and trends in how the ecosystem changes over time.



Discussion Questions

1. What patterns do you notice in the bark beetle and non-resistant tree populations?
2. How might having more non-resistant trees in the forest affect the future of the ecosystem?
3. What do you predict would happen to the forest if resistant trees did not increase in number?



Student Investigation

Rounds 6–10: Resistant Trees Become More Common

Scientists discover that some pine trees possess genetic traits that make them more resistant to bark beetle attacks. As susceptible trees die, resistant trees make up a larger percentage of the forest.

Dice Roll Rules:

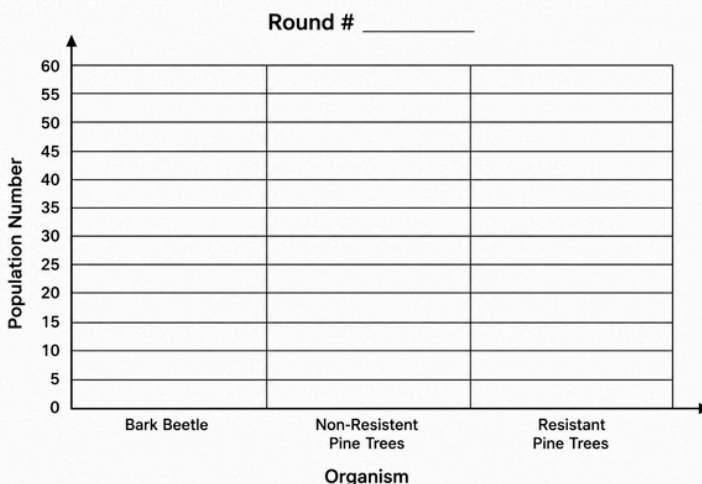
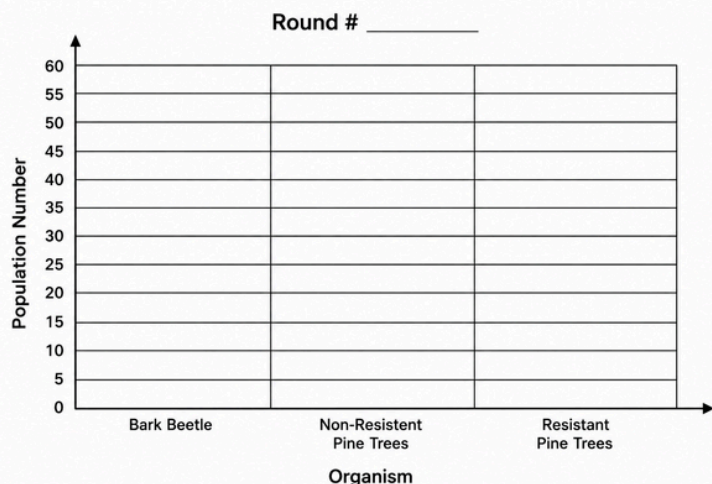
1–3: Bark beetles continue spreading to the remaining non-resistant trees. Add 5 beetles and remove 3 non-resistant trees.

4–6: Resistant trees slow the outbreak. Remove 10 beetles. The resistant trees survive because their inherited traits help protect them from beetle infestation.

Your starting Population will be the numbers from Round 5.

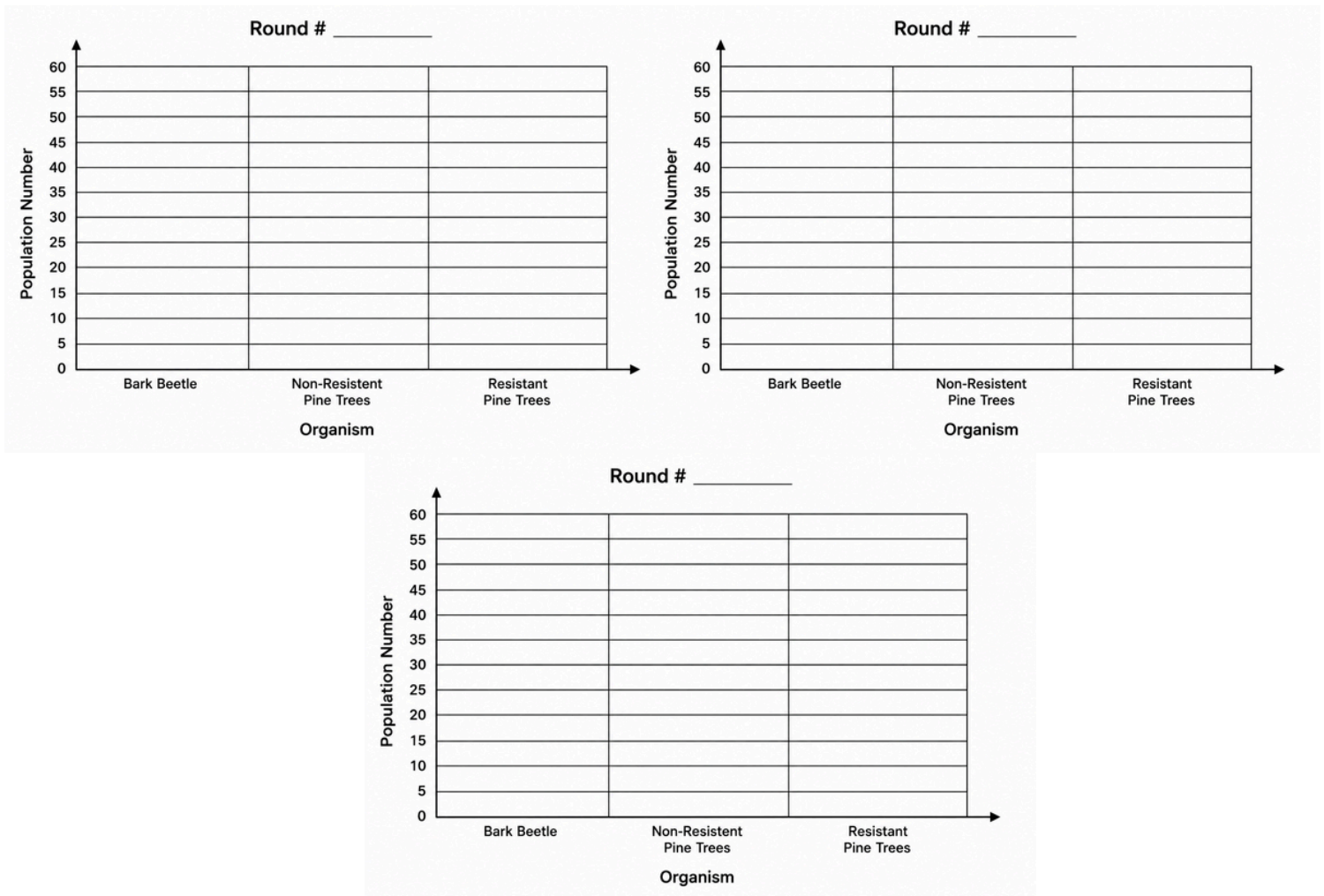
	Starting Population	Round 1	Round 2	Round 3	Round 4	Round 5
Pine Bark Beetles						
Non-Resistant Pine Trees						
Resistant Pine Trees						

Use the data you collected during each round to create a bar graph showing the changing populations throughout the investigation. Use the same three colors for bark beetles, non-resistant trees, and resistant trees each time, then compare your graphs to identify patterns and trends in how the ecosystem changes over time.





Student Investigation



Discussion Questions

1. How did the population of resistant trees change throughout the investigation, and what does this reveal about the role of genetic variation in helping species survive environmental challenges?
2. How did changes in the bark beetle population affect the populations of non-resistant and resistant trees? Use evidence from your data and graphs to support your answer.
3. How does this investigation demonstrate the process of natural selection or “survival of the fittest”?
4. Based on your results, what do you predict would happen to the forest ecosystem if bark beetle outbreaks continued over many generations?