

Changing Planet: Bark Beetle Outbreaks

Background

Mountain pine beetles (or pine bark beetles) are native to North American trees and an important component of the forest ecosystems. However, over the past 15 years the pine beetle population has grown faster than the local ecosystems can tolerate. The range of these beetles has also expanded. The result of these increases is that large stands of mature pine trees are being killed off by these aggressive and hungry pests.

In this investigation you will explore the causes in the population increase, the relationship between the beetles and their host trees, and the challenges to eradicating the beetle population.

Lesson Questions

- What is the relationship between the mountain pine beetles and their host pine trees?
- What causes the mountain bark beetle population to increase and spread?
- What are the possible solutions to saving a stand of pine trees from a mountain pine beetle epidemic?

Materials per group of 2 or 4 students

Internet Connection

Bark Beetle Outbreaks game

Scissors to cut up game pieces (if necessary)

Graph paper

Colored pencils

Lesson Procedure

Part I: Getting to know the Perpetrator

To learn more about the mountain pine beetle, visit the Canadian Forest Service Mountain Pine Beetle page at: <http://cfs.nrcan.gc.ca/pages/49> and visit the Colorado State University Mountain Pine Beetle page at: <http://csfs.colostate.edu/pages/mountain-pine-beetle.html> (click on the PDF called *Mountain Pine Beetle*). Answer the questions below after visiting these two pages.

1. What role does the mountain pine beetle have in the food chain/web of its local ecosystem?

2. Describe the life cycle of the mountain pine beetle include its invasion of a pine tree within the cycle.

3. What is a pheromone, and how does a mountain bark beetle use it?

4. How long is the average life cycle of the mountain pine beetle?

5. How do climate conditions affect the life cycle of the mountain pine beetle?

6. Why are mountain pine beetles only attracted to certain trees?

7. How does a mountain pine beetle infestation kill a tree?

8. During a mountain pine beetle epidemic, how many trees can be killed the following year from the beetles emerging from one tree?

How many years after the original infestation of **one tree** will more than 100 pine trees die from that single infestation?

What does that mean for a forest that has many infested trees?

Part II: A Battle in the Woods

In this part of the lesson you will simulate the losing battle between the mountain pine beetle and their host pine trees.

Procedures and Rules of the Game:

- This game can be played with 1 student (trees in a forest) against another student (beetle population), or two students (trees in a forest) against 2 students (beetle population).
- Obtain a set of game pieces from your teacher, and if necessary cut them apart. There are 30 Action cards; 15 Pine Trees; and 50 Pine Bark Beetles.
- Shuffle all the Action cards before playing.
- Begin play with 15 trees in the forest spread out on a desk or table.
- Play begins when a beetle draws a card, and proceeds with the action. Next, a tree draws a card and proceeds with the action.
- If a tree has 5 beetles on it, it is considered dead.
- Play continues until the trees are all killed off by the mountain pine beetles. Keep track of the amount time it takes to kill off all the pine trees. Action cards may need to be reshuffled and used again in order to complete the game. Keep notes as the game progresses so you can reflect upon the game in detail once the game is over.
- At the end of the game return all the game pieces as directed by your teacher.

Game Analysis:

Based on the *Changing Planet: Bark Beetle Outbreaks* episode and the readings from Part I, compare the results of your game to what actually takes place in the pine forests. What was accurate? What aspects of this epidemic did the game miss?

Why were you asked to keep track of the amount of time it took to complete the game? How did the amount of time you needed to complete the game compare to the amount of time other teams in the class needed to complete the game? Why do you think there was variation in the amount of time needed to complete the game?

Part III: An Epidemic Cycle

As you've learned the mountain pine beetle is a native species and an intricate part of a sophisticated forest food web. But when the conditions are just right, their population can grow out of control, and that's not good for the resident pine trees. In Part I, question #8, you saw how quickly a balanced beetle population can grow out of control, but what would happen if one of the necessities for a growing population was limited?

There are limiting factors that can control the mountain pine beetle population, and includes woodpeckers, cold winters & wet summers, hot forest fires, fungi and nematodes, a lack of host trees, the natural defense of the pine tree, and natural barriers such as mountain ranges. Chemical controls (insecticides and synthetic pheromones) have been somewhat effective, but the naturally occurring limiting factors are more productive controls. Once a limiting factor has an effect on a mountain pine beetle population, the population declines, and the pine tree population has a chance to return. Keep in mind that in order for mountain pine beetle populations to stay in check, 97.5% of all off spring must die. If only 95.5% die in a year, it can prompt an outbreak.

According to the *Mountain Pine Beetle Mania* teacher resource from the National Parks of Canada, there are 4 phases of an epidemic cycle that can be identified in a mountain pine beetle epidemic. They are:

1. Endemic phase – very low populations of beetles randomly attack weak and old trees throughout the forest. Volume growth of trees still remains higher than what is being killed by the beetle.

Timeline: this stage can last for decades. (For this example, use 10-20 years.)

2. Incipient phase – increased migration of beetles from infested areas, favorable weather conditions (warm winters), and decreased effectiveness of natural controls (e.g. bird predators) cause increased numbers of infested trees.

Timeline: this stage can last for 2-3 years.

3. Epidemic phase – usually only in areas with many mature host trees. Large population outbreaks of beetles cause wide-scale tree mortality.

Timeline: this stage can last several years if there are enough hosts available.

4. Declining phase – a lack of host trees or unfavorable climate conditions (e.g. cold winters) cause increased beetle mortality.

Timeline: this stage can last a few (2-3) years and leads back to the endemic phase.

Using these definitions and a piece of graph paper, sketch the pattern the mountain pine beetle follows in becoming an epidemic in a forest. Your graph should have the population level of the mountain pine beetle on the y-axis and time in years on the x-axis. Draw a line on the graph to represent the change in population level over time as the mountain pine beetle passes through each phase and **label** each section of the line on the graph with where each of the phases is represented.

Next, use a different color and on the same graph sketch another line that models the following scenario (you may also do this on a separate piece of graph paper):

Mark a few vertical lines along the x-axis representing several years of late fall or early spring of -30 degrees C (-22 degrees F) or lower temperatures that kill off many of the larvae during the epidemic phase of a beetle epidemic cycle. Now re-draw the stages of the mountain pine beetle epidemic, showing how the mountain pine beetle population will change because of these years of weather effects. Be sure to label each section where the phases are represented.

How is this graph different than your first one?

Part IV: Growth of the Mountain Pine Beetle Epidemic

As you saw above in your calculation in Part I and in creating your graph in Part III, in a short time the mountain pine beetle can decimate hectares and hectares of pine trees in our forests. Refer to the 1996-2009 Spread of Rocky Mountain Bark Beetles maps to analyze the spread of the mountain bark beetle of the period of time of 1996-2009.

1. Orientate yourself to the maps. What part of the United States is represented in these maps?

Using a physiographic map of this region or Google Earth describe the shape of the land.

2. Look at the map symbols. What do represent? (Hint: use the Internet to look up the acronyms.)
3. Observe the change in quantity of mountain pine beetle over the period of 1996-2009. In the space below, sketch a graph of the changes over the period of time. Decide on a unit and a scale for the vertical (y) axis, and place time on the horizontal (x) axis. Label the epidemic stages on your graph.

4. You are an entomologist working for the U.S. Forest Service and realize that the mountain bark beetle is taking over our pine forests. You are shocked at what you see in these maps, and know that a solution is needed to stop this epidemic. Use the space below to write a report to your colleagues addressing the epidemic and include in your report the following information. Refer to all the resources you used throughout this lesson to construct your report.
- Additional information needed to make a full assessment of the reason for the epidemic, along with the reason why you would like this information and what you are looking for in this data (*Hint: specific tree species susceptible to infestation, past temperature data, precipitation data, other biotic & abiotic factors, etc*)
 - The dangers posed to those who want to visit these forests
 - Possible controls for the epidemic
 - Forecast for the future of this forest in regards to this epidemic