New Activity 3

The Disease Triangle

Sunshine State Standards

SC.5.L.15.1: Describe how, when the environment changes, differences between individuals allow some plants and animals to survive and reproduce while others die or move to new locations.
SC.5.L.17.1: Compare and contrast adaptations displayed by animals and plants that enable them to survive in different environments such as life cycles variations, animal behaviors, and physical characteristics.
SC.7.L.15.2: Explore the scientific theory of evolution by recognizing and explaining ways in which genetic variation and environmental factors contribute to evolution by natural selection and diversity of organisms.
SC.7.L.17.2: Compare and contrast the relationships among organisms such as mutualism, predation, parasitism, competition, and commensalism.
SC.7.L.17.3: Describe and investigate various limiting factors in the local ecosystem and their impact on native populations, including food, shelter, water, space, disease, parasitism, predation, and nesting sites.

Materials

For each student:
3 paper plates.
1 marker.

For the teacher (optional):
2–3 copies of the *Student Page* section (2 pages).
1 pair of scissors.
1 copy of the Teacher Guides (2 pages).

Time Considerations

90 minutes

Behavioral Objectives

Students should be able to do the following:
- Identify the three components of the disease triangle.
- Name the pathogen, host, and environmental conditions necessary for a particular disease to occur.
- Describe how a particular forest management technique can decrease disease incidence in a forest.

Lesson Summary

This activity introduces students to an important forest health concept—the disease triangle. Students participate in an outdoor game where they act as pathogenic organisms infecting "trees" in a model forest. Through this simulation of the dynamics of infection they learn about the importance of pathogen, host, and environmental specificity—the three prerequisites necessary for disease occurrence in an organism.

The disease triangle is an important tool for understanding the dynamics of infectious disease in populations, as much for trees in a forest as for people in a city. Management of disease is effectively carried out by manipulating at least one side of the triangle to reduce the likelihood of infection.

Background

The Disease Triangle

A ***disease*** is a sustained or progressive impairment of an organism's cells or tissues that causes structural or functional abnormalities. Some diseases are superficial, marring only the physical appearance of the plant or animal they infect, while other diseases may take a greater toll by affecting tissues critical to the organism's growth, weakening or even killing the infected plant or animal. A disease occurs when a disease-causing agent, or ***pathogen***, meets the right ***host*** organism under ***environmental conditions*** favorable to disease development.

These three elements, pathogen, host, and environmental conditions, make up the ***disease triangle***. The disease triangle is a concept that illustrates the importance of all three elements—just as there are three sides to a triangle, there are three critical factors necessary for disease to develop.

First, a pathogen must be present in the environment. Disease-causing plant pathogens include fungi, viruses, bacteria, and other microbes. Next, a pathogen must come in contact with a susceptible host. Pathogen-host interactions are often very specific, some pathogens having evolved to attack only a particular genus or even species of organism. If an appropriate host cannot be found, the disease will not be present, since the pathogen is missing its food source.

Additionally, even if a species is susceptible, not all individuals within that species will have the same level of susceptibility. An individual tree may have genes that defend it against infection. This is known as ***resistance***. Finally, the right environmental conditions must be present for the pathogen to cause disease. Many pathogens thrive in conditions that stress host trees: flooding, drought, imbalanced nutrition, inadequate sunlight, and wounds, for example, can induce stress or injury in host plants, making them vulnerable to disease.

In this activity, students explore the relationship between pathogens, hosts, and the environment over time, by playing an interactive game. Two organisms, the pitch canker fungus and the oak leaf blister fungus, are used to demonstrate this relationship. For a similar game that explores insect damage on trees in the forest, see *Resources and References*.

Pitch Canker and Oak Wilt

Pitch canker is a disease that affects pine trees. The pitch canker fungus, *Fusarium circinatum*, favors slash pine trees, although it can be hosted by all species of southern pines including longleaf, loblolly, and sand pine. The fungus releases airborne ***spores*** that germinate in entry points upon pine trees such as wounds caused by insect **herbivores**, lightning or wind damage, or mechanical injury from equipment. Once inside a tree, the fungus feeds upon woody stem and branch tissue causing lesions, or cankers, to form. The diseased tissue in the cankers becomes soaked with resin, or pitch, so much so that the pitch begins to seep out of the cankers—this characteristic bleeding is a symptom of pitch canker disease (Figure 10).

Signs of pitch canker disease in trees include whole branches dying off—their needles turning brown, and the tree developing "flags" of dead branches. If the infection is severe, the pine may die of the disease. The fungus requires warm, wet weather to release its spores into the environment, and host wounds are necessary to facilitate infection.

Photo: L. D. Dwinell, USDA Forest Service, Bugwood.org l

Figure 10. Pitch soaking: This branch is soaked with resin from infection. Resin that has seeped out of the canker forms a clotted, sticky, white residue on the branch.

Pitch canker disease is problematic because it can severely impact pine plantations. In the Southeast, slash pine plantations are particularly vulnerable. In California, the much-valued ***native*** Monterey pine is heavily impacted. Furthermore, since Monterey pine is grown internationally on timber plantations, pitch canker is a disease that concerns forest managers around the world.

Oak leaf blister is another fungal disease. The fungal pathogen, *Taphrina caerulescens*, produces light green or brown-colored blisters on the leaves of susceptible oak trees in the spring (Figure 11). During the summer, these blisters produce microscopic spores that can create a white or yellow powder on the oak leaves. The spores are carried to new leaves by wind or rain. Spores remain dormant on twigs or in bud scales on new host trees through the fall and winter, waiting for cool, wet weather to germinate and infect young leaves produced in the spring. While this disease does not typically kill oak trees, oak leaf blister can cause early defoliation in late spring or early summer. Oak leaf blister is often called a cosmetic disease, because it may appear ugly, but does not substantially affect infected trees.

Photo: Andrew J. Boone, South Carolina Forestry Commission, Bugwood.org

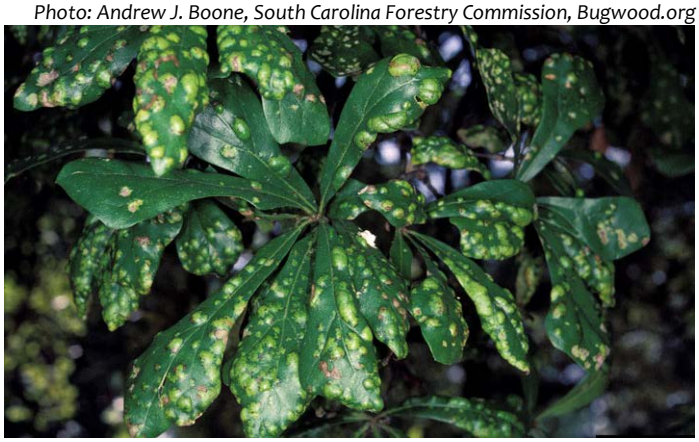

Figure 11. Beauty and the blister: Although oak leaf blister looks alarming on oak leaves, it does not jeopardize the tree's health.

Ecosystem health: Does the disease matter?

Disease is a natural occurrence—it is a function of an ***ecosystem*** containing multiple interacting parts. Fungi, bacteria, viruses, nematodes, and various other microorganisms prey upon plants and animals, and may infect them with varying degrees of severity. Nutritional deficiencies and other ***abiotic stressors*** may also trigger disease in organisms. Is disease always a bad thing?

While disease-causing agents are often seen in a negative light, there are positive and even indispensible roles that these agents play. They place adaptive pressures on organisms, such that those plants and animals with adaptations against infection are selected for, and those that are poorly adapted are disadvantaged. Apart from the role that infectious agents have played in organismal evolution, on a day-to-day basis pathogens are directly or indirectly responsible for ***decomposition*** in ecosystems. Death and subsequent decomposition recycles valuable matter in an ecosystem and allows living organisms to flourish.

It may not be easy to visualize bacteria or fungi infecting trees. However, the impacts, both positive and negative, of tree diseases cannot be overlooked. They are as significant as diseases in humans in terms of the effects they have on populations and ecosystems. In some ways, it may be easy to teach about tree diseases using human diseases as an analogy. However, there are limitations to this strategy—while it may be equally true that disease agents place selective pressures on individuals, and that individual deaths occur to the advantage of a population, it does make a difference when talking about individual humans as opposed to trees. And in both scenarios, while some level of disease is always present in the system, be it forest or city, an epidemic that can decimate populations has severe consequences.

Getting Ready

- Read the *Background*, *Doing the Activity*, *Teacher Discussion Guide, Teacher Game Guide*, and *Student Page* sections to familiarize yourself with the material.
- Prepare the supplies outlined in the *Materials* section.
  - For each student:
    - 3 paper plates.
    - 1 marker.
  - For the teacher (optional):
    - 2–3 copies of the *Student Page* section, depending on the size of the class.
    - 1 pair of scissors.

    Make enough copies and to cut out pathogen cards for each student.
    - 1 copy of the *Teacher Discussion Guide* and *Teacher Game Guide* (2 pages) for your convenience while doing the activity.

Doing the Activity

90 minutes

1. Ask students what they think a disease is. The *Background* section provides a definition that you may use in class. Additionally, the *Teacher Discussion Guide* on page 34 has information to help you facilitate a discussion on disease development; you may wish to make a copy of the page as a quick reference during class. Be sure to cover each of the topics outlined and clearly indicate to students that a pathogen, an appropriate host, and the right environmental conditions are necessary for disease to occur on a tree. Also, point out the importance of tree resistance to disease.

2. Tell students that they are going to take part in an activity to understand how disease spreads through a forest. Hand out three plates and a marker to each student. Ask each student to draw a big "P" on the top of two plates. The "P" plates represent pine trees. Ask the students to draw an "O" on the top of their third plate. The "O" plates represent oak trees.

Collect all the plates; write "R" on the bottom of about a quarter of the "O" plates and about a quarter of the "P" plates. This "R" represents resistance in a tree. You can also prepare these "trees" before class to reduce the activity time. See *Extension Ideas* for a student variation on making paper plates.

Take it outside

The rest of this activity requires open space for students to move around. Consider taking the activity outdoors to maximize students' ability to have fun and learn at the same time.

3. Inform students that each of the paper plates represents a tree; a plate with a "P" represents a pine tree and a plate with an "O" represents an oak tree. Ask students to help you create a pine-dominated forest by scattering the plates on the ground. Make sure none of the plates are overlapping and the "P" and "O" sides are facing up.

4. The remaining steps instruct you to carry out this activity using both pitch canker and oak leaf blister to explain concepts. If you wish to conduct this activity with younger audiences, merely omit any references to pitch canker. In other words, *all* students will play the roles of oak leaf blister fungi and you need only read out the description of oak leaf blister fungus from Table 1 and make copies of only page 1 of the *Student Page* section, which includes information about the oak leaf blister fungus.

Ask each student to pretend to be one of two pathogens. Split the class in half and designate one half as the oak leaf blister fungus and the other as the pitch canker fungus. Tell each group of students to listen carefully to the description of the disease their fungus causes. You may ask students to write down the pathogen, host, and environmental conditions necessary for their disease to form (Figure 12) or you may hand out copies of the pathogen cards found in the *Student Page* section as a memory aid. Read both statements that follow (Table 1) out loud to the class, placing emphasis where indicated in bold caps.

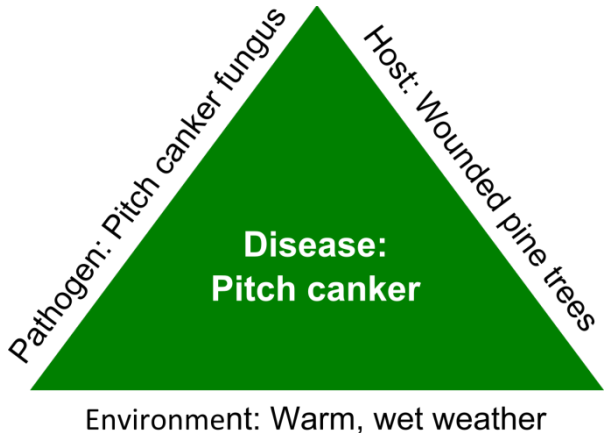

Figure 12. You may ask students to make a disease triangle memory aid as shown here for pitch canker. Ask students to draw a triangle and complete each side with the appropriate host, environmental conditions, and pathogen for their diseases.

Table 1. Diseases of trees.

Oak leaf blister	The disease, oak leaf blister, is caused by a fungus that grows on **OAK LEAVES. COOL, WET WEATHER** is needed for this fungus to germinate on new, young leaves each year.
Pitch canker	The disease, pitch canker, is caused by a fungus that grows within pine wood and bark tissues by entering through wounds in the stems and branches. **WARM, WET WEATHER** is needed for this fungus to germinate and infect **WOUNDED PINES.**

5. Tell students that as pathogens they will try to spread disease in the forest, but point out that not all of the trees are the same. Remind them that some are oak trees and others are pine trees. The pitch canker fungus only attacks pine trees and the oak leaf blister fungus only affects oak trees. In addition, some of the hosts have genes that make them resistant to oak leaf blister or pitch canker. A resistant tree is identified by an "R" on the bottom of the plate. Remind students of the disease triangle by asking them to identify the three elements necessary for their disease to occur and how each is represented in the game: a pathogen (each student), a fitting host (the correctly lettered paper plates without an "R" on the back), and the right environmental conditions (read out loud by you) are necessary for the disease to develop and spread.

6. Ask the students to stand around the edges of the "forest" with their markers in hand. Read the following instructions to the students.

"We are all standing around the edges of a mixed hardwood forest. The paper plates you see in front of you represent the trees in the forest. Would someone like to remind us what the "P" on the paper plate stands for? *(Pine)* And what about the "O," what kind of tree does that represent? *(Oak)*.

"Now, all of you are going to play the roles of fungi that feed on trees. You are pathogens, because you can spread disease to trees. You travel in the form of tiny, seed-like spores through the wind. When you land on a tree, you try to germinate, infect the tree and cause disease.

"I am going to tell you what the environmental conditions are like for each round. If the environmental conditions are right for you, the fungus, you must travel into the forest in search of your preferred host tree. I will tell you how many steps to take if the environmental conditions are right. You must take each step with one foot in front of the other, heel touching toe. Once your foot touches a plate that is a suitable host, you may flip the plate to see if it is resistant. If the tree is resistant (has an "R" on the bottom of the plate), you may not infect the tree, unless otherwise stated in the round. If the tree is susceptible (not resistant or has nothing on the bottom of the plate) you may draw a small "x" on that tree. The "x" shows that that tree is diseased. Make sure you place the plate back on the ground with the top facing up.

"Pitch canker disease may eventually kill a tree. If the tree is infected three times, in other words, if you are the third pitch canker fungus to mark an "x" on a pine tree, fold up the plate so that others may know it is dead and cannot be infected. Oak leaf blister fungus only causes a cosmetic defect; this does not affect the life of the tree. The oak leaf blister fungus may infect oak trees many times, no matter how many "x" marks are already on it.

"If you reach a tree and still have steps remaining in that round, you may infect that tree and keep on moving toward another one. If you reach another tree in the same turn, you are allowed to infect the second tree as well. Multiple students may infect a tree during each round, but each student, after infecting a tree, cannot revisit that tree again."

7. Using the Teacher Game Guide on page 35, read the first round to instruct the pathogens on what the environmental conditions are like, and whether or not they can move. Allow ample time for students to move through the forest and infect trees before reading the next round. Continue through all 10 rounds.

8. After, the activity, ask the students to gather around the forest once again. Ask them to think about what was necessary for disease to form. Review the disease triangle again. Guide a discussion about how the forest changed and what made pathogens successful or unsuccessful. Use the following questions to guide your discussion. Note that the answers to some of these questions will differ depending on whether you conduct the advanced or simpler version of the activity. Use the appropriate suggested answers to guide discussion.

a. How many trees were killed?

b. What types of trees were killed?

c. Does this change the ***composition*** of the forest? In other words, does the forest look different now than it did before?

Advanced version: There are now more dead trees in the forest. If the pitch canker fungus has been particularly effective, the forest has changed from a mixed pine/oak forest to one that is dominated by oaks.

Simple version: The forest composition has not changed, although some of the oaks are now diseased with oak leaf blister fungus.

d. If the forest were made up of only pine trees, what would have happened?

Advanced version: There would be a drastic increase in the number of dead trees in the forest, and only resistant pine trees may have remained standing.

Simple version: The oak leaf blister fungus, having no available hosts, would not have been able to affect the trees. The forest would remain unchanged.

e. What made you successful or unsuccessful at infecting a tree?

There needed to be appropriate environmental conditions for the fungus to travel. There needed to be available host trees to cause a disease. Resistant trees hindered the fungus' spread.

f. Were trees closer to a recently infected tree more likely to become diseased by a pathogen than trees on the other side of the forest?

Yes, proximity to diseased trees makes it easier for a fungus to travel from infected host to new host.

g. Do you think the same number of trees in the forest would have been killed if the trees were farther apart?

No, trees spread farther apart would have been harder to infect.

h. If you were planting trees in a park, what could you do to decrease the likelihood of disease?

Space them out and plant several species. Plant trees resistant to disease if possible.

9. You can rearrange the trees and conduct the activity again, or try the advanced version if you used the simpler version the first time. Use the *Disease Triangle* visual presentation on the website (*Resources and References*) to help students understand what forest management is. Choose a management technique to use in the activity. For example:

- Have students "plant fewer trees" by laying out fewer paper plates on the ground.
- Have students "plant trees further apart" by spacing out the paper plates.
- Have students "thin out an overcrowded forest" by going into a "pre-planted" overcrowded forest and removing selected paper plates.
- Have students "plant resistant trees" by selectively laying out only plates labeled with an "R."
- Repeat steps 6 through 8.

10. Discuss the changes in the forest and the impact of the selected management decision. Use the following questions to guide a closing discussion.

a. How many trees were killed?

b. How many trees were infected but not killed?

c. Did more trees survive using the selected management strategy?

d. Was this strategy successful?

e. What other ways might forest managers try to prevent or control disease?

Teacher Discussion Guide

Use the following questions to facilitate discussion throughout this activity. You may use all or some of the provided details to fit the scope of the discussion.

General disease

1. What kinds of diseases do people get?

Colds, flus, ear infections, cancer, heart disease, etc.

2. What causes them?

Bacteria, viruses, fungi, and other microbes cause many diseases. Environmental stressors and genetic predisposition contribute to others.

3. What do we do to protect ourselves against infections?

We may wash our hands, take vitamins, maintain a healthy diet, get plenty of sleep, or stay away from others who are sick.

Appropriate hosts

4. Do humans and cats get all of the same diseases?

No, they don't. For example, cats are susceptible to Feline Immunodeficiency Virus (FIV). There is no evidence that humans can contract this disease. Most diseases are species specific. However, some pathogens may act upon different species, usually related ones.

Environmental conditions

5. If someone spends the whole night awake outdoors in the rain, do you think he or she would be more likely to catch a cold than someone who hasn't?

Yes, staying outdoors in the rain puts stress on the body and makes a person more susceptible to attack by pathogens such as the cold virus.

Pathogens

6. Why are some sick students told not to come to school?

You can only catch a disease like the flu if you're exposed to the pathogen—in this case, the flu virus. Sick people carry the virus in their bodies and can release it into the air and onto surfaces by sneezing. The virus can then be transferred to other people who become new disease hosts. One method to stop disease from spreading is to remove pathogen carriers from the disease triangle equation—such as by asking sick students not to come to school while they are contagious.

Resistance

7. Do all people have the same likelihood of catching a disease?

No, some people may be resistant to a disease—that means their bodies may be more capable of fighting off the pathogen before it can do any damage. Some people may be genetically resistant to a disease. For example, during the 1300s, the Black Plague spread throughout Europe. Although everyone in a town may have been exposed to the deadly disease, only the susceptible members of the population died. two thirds of the Europe's population survived the Black Plague.

As another example, how many of us in the room have had chicken pox? Those who have already had chicken pox are now immune, or resistant, to the virus, and won't be affected by it again. Those who have never had chicken pox should be careful not to come in contact with those who currently have it, because their bodies have no resistance to the disease.

Trees and Disease

8. Do trees get diseases?

Yes. Trees are living organisms, just like humans and cats, and they are just as vulnerable to diseases.

9. What do you think may cause them?

Bacteria, viruses, fungi, and other microbes.

10. Do you think some kinds of trees are better hosts than others for a certain disease?

Yes. Refer to question 4. Trees have co-evolved with many other organisms, including pathogens such as fungi and bacteria. Specific trees have built up specific resistant mechanisms to some pathogens, and likewise, some pathogens have evolved special mechanisms to attack particular species of trees.

11. Can trees be stressed like humans?

Yes. Refer to question 5. When organisms are environmentally stressed, they are weakened and less able to defend themselves against attack by pathogens.

12. Can trees exhibit resistance?

Yes. Refer to question 7. Some trees have genetic resistance to disease, and others can fight back against a disease after being previously exposed to it. One of the worries for growers—especially those who plant crops such as corn, potatoes, oranges, or pines—is that if a disease hits one plant, it might spread to the entire crop. If the plants are all genetically similar (the seeds come from the same batch of plants and are all related), or if they are genetically identical clones, they may have no resistance to a particular disease once it enters their field or plantation. Tree genetic diversity is a way of ensuring that there will be at least some resistant individuals in a population.

Teacher Game Guide

Read the text for each round out loud to the class. Give students time to move between rounds.

Round 1: "It is early springtime, and the weather is damp and cool. Move **8 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Only the oak leaf fungus is able to move and cause infection.

Round 2: "Spring continues, but although it is cool, it hasn't rained in a few weeks. Move **2 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Neither the pitch canker fungus nor the oak leaf fungus is able to move.

Round 3: "It's now summertime, and there have been many thunderstorms. A lot of trees have broken branches on them. The air is hot and humid."

Representing the thunderstorm, you should walk through the forest crumpling up some of the paper plates (both oaks and pines), indicating that these are trees with broken branches. Alternately, have a student volunteer to be the storm and crumple some plates for you.

"Move **3 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Only the pitch canker fungus is able to able to move and cause infection.

Round 4: "There's an outbreak of eastern pine weevils. These beetles chew on pine tree twigs and cause wounds all over the trees while feeding and laying eggs."

Representing the weevils, again walk through the forest with a pencil to pierce holes representing weevil damage on the trees. Remember to only damage pine trees this time. Alternately, have a student volunteer to be the eastern pine weevils.

"Move **4 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Only the pitch canker fungus is able to able to move and cause infection.

Round 5: "It's now late fall and there has been a dry spell. The temperature is also dropping. Move **3 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Neither the pitch canker fungus nor the oak leaf fungus is able to move.

Round 6: "After a long cold winter, it's now spring again. There's new growth on the oak trees and there have been some cool spring showers. Move **10 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Only the oak leaf fungus is able to move and cause infection.

Round 7: "The forest is cool and damp because it has been raining persistently for weeks this early summer. Move **9 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Only the oak leaf fungus is able to move and cause infection.

Round 8: "It's the beginning of summer and the air is hot and dry. Move **3 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Neither the pitch canker fungus nor the oak leaf fungus is able to move.

Round 9: "It's timber harvest season! A timber company has driven giant tractors and other harvesting machines into the forest. Operating heavy machinery is difficult, and the harvesters have accidentally scraped against some trees and broken a few branches of neighboring while cutting down the trees they need. There hasn't been a rainstorm in weeks, and the forest it quite dry, though hot."

Representing the timber harversters, walk through the forest crumpling or damaging paper plates representing oaks and pines. Take away a couple of plates as your "harvest." Alternately, have a student represent the harvesters.

"Move **5 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Only the pitch canker fungus is able to move and cause infection.

Round 10: "Towards the end of summer there have been thunderstorms all month. It is humid and windy. Move **7 STEPS** if these conditions are right for you. If you reach a tree, remember to check for resistance."

Only the pitch canker fungus is able to move and cause infection.

Assessment

Using observations of students' behavior and responses during discussion, check that they can do the following:

- Understand that tree disease only occurs if a pathogen attacks a specific host under specific environmental conditions.
  Seen in students' actions during each round of the game.

Note that this is a group assessment rubric. To assess students individually, consider one of the following options.

- Ask each student to write a "wanted" ad from the perspective of the pathogen they played. They should include the environmental conditions and host needed.
- Each student can research a common disease found in trees. See *Resources and References* for ID cards that will give students material to work with. Students should include information about each of the three corners of the disease triangle for the disease card they are assigned.

Extension Ideas

- The preparation of paper plates representing pines and oaks can be an art activity carried out the day or week prior to conducting *The Disease Triangle*. Hand each student three paper plates. Ask them to paint a pine tree on each of two plates and an oak tree on the third plate. Pine trees are painted tall and spiky with dark green and dark brown paint. Oak trees are painted broad and fuzzy with light green and light brown paint. These can now be used to build the forest as described in the activity.

- Tell students to pretend they are natural resource managers. Their agency just inherited 200 acres of longleaf pine forest. The longleaf pine is a highly valued native tree that is an integral part of southeastern ecosystems. As a result, managers do not want to develop this land and would like to maintain it as a natural area devoted to longleaf pine restoration. Two miles away from the north end of the property, a land owner has discovered an outbreak of pitch canker on his slash pine plantation. Ask students to research pitch canker disease. Students should decide if action needs to be taken to protect the longleaf pine forest. What are the susceptible hosts for the pitch canker fungus? Would longleaf pine trees be affected by the fungus if it spreads from the slash pine plantation? Facilitate a discussion with students about how they would approach longleaf pine management with the owner of the slash pine plantation. Would there be conflicting interests between these two kinds of land managers? How might they cooperate?

Resources and References

- The University of Florida's SFRC Extension website for educators includes several related resources:
  - A *Disease Triangle* visual presentation complements this activity.
  - For another activity that models the disease triangle with a game see *Activity 3: How to Eat a Forest –Southern Pine Beetle-Style*, available in *Beyond the Trees*.
  - Several examples of tree disease, including pitch canker and oak leaf blister, are found in the *Pocket ID Guide*. These flash cards can be used to test students' understanding of the three sides of the disease triangle.

  Visit http://sfrc.ufl.edu/extension/ee/foresthealth.html

- More information on the disease triangle and other aspects of forest pathology and health, are provided at James. J. Worrall, USDA Forest Service plant pathologist's website *Forest & Shade Tree Pathology.* Specific information related to this activity is found under "General Topics," "Disease, pathogen, names."
  Visit http://www.forestpathology.org/

Photo: Larry Kohrnak

Pathogen Cards

Instructions

Make copies and cut out the following cards to hand out to students as a reference while playing the disease triangle game. If you are working with younger audiences and want to conduct a simple version of this activity, only make copies OF page 1.

Oak Leaf Blister

Oak leaf blister is a disease caused by the **oak leaf blister fungus**. This fungus only affects **oak trees**. The oak leaf blister fungus produces microscopic, seed-like spores on oak leaves. These spores are spread by the wind. The spores need **cool, damp weather** to germinate and infect new oak leaves in the spring.

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Pitch Canker

The disease, pitch canker, is caused by the **pitch canker fungus**. The fungus releases microscopic, seed-like spores into the wind. **Warm, wet weather** is needed for germinating spores to infect **wounded pine branches and stems**. Wounds are created by stormy weather, human-caused damages, or insect feeding. As the fungus grows it makes the pine develop sunken scars called cankers that "bleed" out pine resin, or pitch. A tree with many cankers can weaken and die.

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