Activity 2
Six Bits of Abiotics

Sunshine State Standards
Science (9-12): SC.912.L.17.7, SC.912.L.17.16, SC.912.L.18.11
Social Studies (9-12): SS.912.G.5.2
Reading/Language Arts (9-10): LA.910.1.7.4, LA.910.2.2.2
Reading/Language Arts (11-12): LA.1112.1.7.4, LA.1112.2.2.2

Materials
For each group of six students
1 copy of the Student Page (1 page).
For the teacher
1 pair of scissors.
Chalkboard, large sheets of newsprint, or other means of drawing and presenting information to the class.
Writing utensils.

Time Considerations
Part A: 10 minutes
Part B: 25 minutes
Part C: 25 minutes

Behavioral Objectives
Students should be able to do the following:
• Cooperate as a group to solve a problem.
• Describe skills that enhance cooperative work.
• Analyze the information coming from different members of each group.
• Synthesize information to solve the problem posed by a six bits activity.
• Identify the parts of an abiotic system as the nouns described in a six bits scenario.
• Form cause-effect linkages between the noun-object components identified in a concept map.
• Draw a concept map that describes the systems interactions in the six bits scenario.

Lesson Summary
In this activity students learn about abiotic environmental features and their effects on forests, and about some abiotic forest stressors. Students apply what they have learned to solve a mystery about a particular abiotic threat to urban forests—air pollution. The mystery is embedded in a collaborative learning exercise known as a six bits puzzle. Groups of six students are given six cards. Each student’s card holds three seemingly unconnected snippets of information. By sharing information and working together, students put together the clues on their cards to solve the mystery.

A two-part discussion process helps students conceptualize the problem they have just solved. In the first part of the discussion, students create a concept map of the abiotic interaction represented in the six bits puzzle. The concept map shows students how various properties of an urban forest system are connected, and how a phenomenon such as pollution may affect urban forests. The second phase of the discussion session allows students to reflect on how cooperative behavior in groups helps them reach solutions. The six members of each group all have information that makes them partial experts on certain aspects of the mystery, but without acting as a group, they do not have enough information to solve the puzzle. You can help students recognize that they, too, are components of a system, able to influence each other to reach an answer that none of them can find on their own.

Background
Abiotic Interactions in a Forest
A tree is exposed to numerous environmental conditions that have an impact on its growth and overall health. These environmental factors are described as abiotic influences because they are nonliving factors. For example, if a tree with high water demands that normally grows in a swamp or floodplain is growing in a water-poor environment it becomes weakened because of limited access to water. What might cause a lack of water? It could be that the tree was planted in the wrong place and is not adapted to its environment or that water withdrawals or drought have lowered the water table. The causes of adequate, insufficient, or excessive access to water, light, nutrients, and other abiotic influences on tree
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growth are not restricted to just that tree—they are features of the greater environment. Just as a tree’s health may be determined by environmental quality, so may the health of a forest. A drought can severely disadvantage an entire forest. It can stress water-dependent trees, but on the other hand, it may positively affect drought-tolerant trees, since they are able to thrive in the drier soils with less competition.

It is important to make the distinction between the effects of environmental conditions on individual trees—each of which may react in unique and specific ways to those conditions—and the impacts upon the entire forest, where the dynamics are vastly more complex in terms of tree species, age classes, and species interactions. It is also important to understand where environmental conditions originate. A tree growing in a cubeful of soil on the side of a street with access to sun, air and water is quite different from a tree growing on the edge of a forest by a river or in the middle of a forest surrounded by weedy invasive trees.

This activity focuses on specific environmental interactions in an urban forest. Development continues to be a prevailing trend of land use. Additionally, people are becoming increasingly aware of the importance of maintaining vegetation within and around their homes and workplaces; for aesthetic reasons; in order to maintain remnants of the original landscape; or to benefit from ecosystem services that trees provide, such as water purification, holding together of soil, and provision of shade. The urban forest is a particular category of forest that includes trees, other vegetation, and animals that form part of the landscape of the city. These forests often form a bridge from densely populated regions to sparser areas where farms, plantations, parks, or forest preserves may be (Figure 11).

Urban forests are significant because they are directly and continually influenced by anthropogenic activities. Construction activities and pedestrian and motor traffic cause soil compaction, which increases pressure on roots while decreasing space for air and water to percolate. Additionally, storm water runoff is channeled along rooftops, gutters, across pavements and roads rather than directly into the soil. The water picks up and transports salts, nutrients, and contaminants between areas as it travels the city. Automobile exhausts, factory chimneys, and other sources release nitrous, sulfur, and carbon oxides; ozone; and other volatile gases. These may combine with other molecules to fall to the ground or may dissolve in rain and travel through waterways.

These stressors are not infectious—that is to say, the diseases or abnormalities they cause on trees do not spread, since the contaminants are not alive and do not reproduce. For instance, ozone intake through leaf pores (stomata) of some trees in urban forests damages cells and causes purple spotting or stippling upon the leaves (Figure 12). The trees may weaken, but similar trees that are farther from the source of ozone will not be disturbed. Different species, and indeed different individuals within a population, have varying degrees of tolerance to abiotic stresses. But when a large area of trees succumbs to the same stressor, it may appear to the observer to be a contagious disease!

Abiotic factors that influence forest health may just as likely include dramatic events such as hurricanes, floods, or fires. While some of these may be triggered by anthropogenic activities, natural disasters also occur. Often, the way to
distinguish between anthropogenic and natural abiotic stressors is to see whether the damage caused in the forest is random or follows some pattern. Pesticide misapplications cause a localized wake of damage and death. Hurricanes, on the other hand, leave wakes so large that local patterns may not be visible, and the damage caused to trees may seem massive, random, and chaotic.

Conducting a Six Bits Activity

This six bits activity operates on the principle of separating a case study or scenario into six partial “bits” of information. Students in groups of six are each given one of the six cards with unconnected facts about the scenario, such that no student knows exactly what the scenario is or what they need to do. One of the cards contains a question. Each group needs to realize that the question written on one of their cards is the key, and that putting together the pieces of information they have will allow them to answer the question. Students are not allowed to look at each others’ cards; however, they are allowed to read them out loud and explain the information that they have to the other members of the group. Some of the facts on the cards are deliberately misleading red herrings that don’t help answer the question, despite superficially seeming to. Only careful connection of the facts will solve the problem.

This cooperative learning activity depends upon all learners playing an integral role to answer the question. Since each group of six receives the same instructions, the discussion at the end of the activity can focus on why some groups worked well and others may have stumbled. The importance of identifying a leader and an awareness of what helps make a good leader also can be discussed. It might be interesting to have some single gender groups and some mixed groups to see how they may function differently. The actual solution to the question is only part of the value of this activity. Some teachers, after performing one six bits activity, have created others to teach various concepts to students. For more examples of six bits activities related to forest health, see Resources and References.

Thinking in systems: Concept maps and partnerships as problem-solving tools

A concept map is a diagrammatic representation of concepts and their linkages to one another. This useful teaching tool lays out for the observer the important items, issues, or component parts of a scenario and has lines and arrows connecting these items to each other to show how they are related. Together, the components and their relationships to each other form a system of interacting parts, so understanding the whole system is made easier by understanding how the pieces fit together. Concept maps may be representations of systems, but they may also be representations of the ways in which people think—individuals may draw conceptual understanding of a system in different ways, and this can point to differences in learning patterns as well as gaps and misconceptions in understanding. Thus, making a concept map helps students consider how a system functions.

This activity allows you to construct a version of a concept map with students, based on simple linguistic devices. A question about abiotic interactions is asked; solving the six bits activity reveals the answer. Both the question and answer can be represented as sentences. Each noun in the sentence becomes a “component” of the system of interactions that provide an explanation to the question. The students, using their six bits of information, can provide more information about each of the noun components of the initial question and answer—each of these sentences contains more nouns that represent more component parts of the system. The concept map drawn this way between nouns and facts known about those nouns can expand farther and farther past the initial starting point and may help reinforce what students learned through solving the six bits activity (see Figure 13 on page 15).

Another system is modeled through the six bits activity. The students in each group are component parts of a “system”; none of them can solve the mystery alone, and they must cooperate with each other in order to come to a solution. Pointing out to students how they functioned together in their groups allows them to reach an understanding about how the quality of interactions affects their ability to solve problems. They also learn that systems operate not just in ecosystems, chemical reactions, and biological processes, but also in everyday interpersonal relationships.

Getting Ready

- Read the Background, Doing the Activity, and Student Page sections to familiarize yourself with the material.
- Prepare the supplies outlined in the Materials section.
  - For each group of six students:
    - 1 copy of the Student Page (1 page).
  - For the teacher:
    - 1 pair of scissors.
    - Chalkboard, large sheets of newsprint, or other means of drawing and displaying information to the class.
    - Writing utensils.
- Cut each Student Page along dotted lines to form packs of six cards for each group.
Part A: Introduction to abiotics
10 minutes

1. Prompt students to list some abiotic features of a forest and how these features might affect the ecosystem. See Resources and References for pictures to illustrate discussion.

   Abiotic forest features include soil, water, air, sun, temperature, climate, and mineral salts—any non-organic component of the ecosystem. Abiotic features support the biotic components of a forest. Soil provides anchorage for tree roots, water transports minerals and nutrients, and so on.

2. Now ask students if they can think of any abiotic stressors to forests—non-organic features that disrupt or damage the health of trees or the whole forest.

   Answers might include drought, wildfire, flood, freeze, air pollution, etc. Natural abiotic resources are always present in a forest, but there may be fluctuations in their availability. For example, droughts and floods both affect the amount of water present in the ecosystem. Anthropogenic disturbances may also alter the availability or quality of abiotic resources, but sometimes they may introduce abiotic features that were never part of the environment, or they may remove features that were necessary for the ecosystem’s proper function. Pollutants are abiotic additions that are not typically found in forests, and fire suppression is unnatural in a fire-dependent ecosystems.

Part B: Six bits of abiotics
25 minutes

4. Hand out a six-card set to each group. Ask them to distribute the cards, face down, one to each person. Once everyone has a card, ask the groups to turn the cards over and work together to find the solution to the puzzle.

5. Circulate throughout the room, noting how leadership develops, what causes difficulty, and the order in which groups finish. Wait for all groups to finish before starting Part C.

Part C: Discussion and reflection
25 minutes

6. Where all the students can see write the question posed by the six bits mystery: Why do Marchwood City’s linden trees have purple dots all over the leaves?

7. Ask one team to send one of its members to the board and write underneath the question that group’s solution to the problem.

8. Confirm with the rest of the class that this was the solution they all came to.

9. Ask another team to send one of their members to underline all the nouns in the question and the answer.

10. Ask another team to send one of its members to fill in a fact about one of the nouns underlined.

11. Ask a student from another group to underline the nouns in the new fact, and write in a fact of his or her own.

12. Continue in this form calling upon students from each group in turn to fill in a fact about a noun that has not yet been underlined. See Figure 13 on the next page for an example of a concept map that results from this process.

13. Explain to students that they have created a system of interacting components that together result in an outcome—in this case, the stippling of linden leaves as a result of ozone pollution. Following are some points you may touch on when describing the system that your students have created.

   In the incomplete example, each noun is an object in the system of interactions that leads to ozone damage on linden trees. Each object is associated with multiple other objects, and the arrows show relationships between the components. Notice the sentences “Coal is a type of fossil fuel” and “[Enzymes] may be destroyed by ozone or SO2.” Alternately, an arrow may be drawn from “coal” to “fossil fuel” or “enzyme” to “ozone” or “SO2” without the superfluous repetition of objects that are already represented by this system.

14. Next focus on the process that enabled each group to arrive at the correct response. Ask the first team to complete the mystery why they think they finished quickly. Ask the last to finish what bogged them down. Explore the role of leadership and what creates leaders. Sometimes it is the
person who has the pencil or the question! Ask students why they were not allowed to show their cards, even though they could read them aloud.

The object of the six bits activity is to build cooperation, even when faced with a seemingly frustrating and impossible to solve problem. Some of the clues are red herrings—they don’t lead to the answer, and are there to misdirect the group’s participants. Likewise, minimal instructions force the group to take charge and figure out what is going on. They might start by asking each other whether they are just as clueless about what to do. One person might mention that they have a question on their card, and when the group realizes that this is unique and different from what is on all the other cards, it sets the ball rolling. What’s the question? Once the group starts to share information and then make connections between the bits, they find their answer.

- Identify the parts of an abiotic system as the nouns described in a six bits scenario. 
  Seen in successful completion of the concept map as outlined in Part C.
- Form cause-effect linkages between the noun-object components identified in a concept map. 
  Seen in successful completion of the concept map as outlined in Part C.
- Draw a concept map that describes the systems interactions in the six bits scenario. 
  Seen in successful completion of the concept map as outlined in Part C.

Note that these are group assessments, not individual student assessments. See Extension Ideas for an opportunity to assess students independently.

**Extension Ideas**

- The six bits scenario posed in this activity briefly mentioned high salt concentrations in water in Marchwood City. Salt is another abiotic factor that affects trees. If the question were posed: “Why does Marchwood City have such high salt levels in the water?” how would this system be drawn?
  Additional information would be required, since the causes and effects of salt accumulation in the environment are not completely discussed in the given activity. Ask students to create a hypothesis as to why salt concentrations in water might go up. Ask them to research the potential sources of salt in cities and the effects high salt concentrations have on trees. Have students individually create a hypothetical system of interactions to describe the scenario in a similar fashion to the ozone system that was discussed in class.

**Resources and References**

- The University of Florida’s SFRC Extension website for educators includes several complementary resources.
  - A visual presentation with images relevant for this activity may be adapted for use in discussion.
  - Two other examples of six bits puzzles that teach forest health concepts are found in New Activity 5: A Changing Forest, in What Is a Healthy Forest? Visit [http://sfrc.ufl.edu/extension/sfrc_extension/index.html](http://sfrc.ufl.edu/extension/sfrc_extension/index.html)
- More information on abiotic tree diseases is found at J. J. Worrall, USDA Forest Service plant pathologist’s website Forest & Shade Tree Pathology. Specific information related to this activity is found under “Main Topics,” “Abiotic diseases.” Visit [http://www.forestpathology.org/](http://www.forestpathology.org/)

**Assessment**

Using the students’ answers during discussion, check that students can do the following:

- Cooperate as a group to solve a problem. 
  Seen in students’ successful completion of Part B as outlined in the Doing the Activity.
- Synthesize information to solve the problem posed by a six bits activity. 
  Seen in successful completion of steps 1 and 2 of Part C in the Doing the Activity.
### Six Bits of Abiotics

#### Instructions

For each group of six students in your class, make one copy of this sheet. Cut the six cards along the dotted lines. Distribute a set of cards for each group—one card per person for each group of six, reminding students that they cannot show others their cards.

<table>
<thead>
<tr>
<th>Do not show this card to anyone else. You may tell someone else verbally what is on your card.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Excess salt taken through plant vessels travels from roots to leaf tips, where the salt is stored.</td>
</tr>
<tr>
<td>• Sulfur dioxide and ozone both form highly toxic compounds that cause enzyme damage to plant cells—these cells then die.</td>
</tr>
<tr>
<td>• Marchwood City derives its energy from a coal-fired plant just outside the city limits.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Do not show this card to anyone else. You may tell someone else verbally what is on your card.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tests of water runoff from Mrytle Town showed high salt concentrations.</td>
</tr>
<tr>
<td>• Why do Marchwood City’s linden trees have purple dots all over the leaves?</td>
</tr>
<tr>
<td>• Marchwood City proudly boasts that nearly 60 percent of its workforce uses bicycles to commute to work.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Do not show this card to anyone else. You may tell someone else verbally what is on your card.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• It is summertime and most trees have green leaves.</td>
</tr>
<tr>
<td>• Chlorophyll is a green plant pigment produced by enzymes.</td>
</tr>
<tr>
<td>• Burning coal releases many gases: volatile organic compounds, nitrous oxides, and sulfur dioxide.</td>
</tr>
</tbody>
</table>

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<th>Do not show this card to anyone else. You may tell someone else verbally what is on your card.</th>
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<tbody>
<tr>
<td>• Patches, dots, or edges of leaf cells die when toxins accumulate in those regions.</td>
</tr>
<tr>
<td>• In autumn, deciduous leaves change color—the whole leaf may turn red, yellow, purple or brown as leaf cells die.</td>
</tr>
<tr>
<td>• Internal salt damage to plants causes leaf edges to turn yellow and then brown.</td>
</tr>
</tbody>
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</thead>
<tbody>
<tr>
<td>• Ozone is a gas formed when volatile organic compounds and nitrous oxides are triggered by sunlight to react with each other.</td>
</tr>
<tr>
<td>• Chlorophyll production stops naturally in the fall and leaves eventually die, since they cannot make food without chlorophyll.</td>
</tr>
<tr>
<td>• Coal is a fossil fuel.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Do not show this card to anyone else. You may tell someone else verbally what is on your card.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sulfur dioxide badly damages pines and birches, but has little effect on cedar and linden.</td>
</tr>
<tr>
<td>• Individual cells lose shape and color as the enzymes inside them are broken down.</td>
</tr>
<tr>
<td>• Plants facilitate gas exchange through stomata—breathing pores that cover the leaf surface.</td>
</tr>
</tbody>
</table>