beetles

Science and Teaching for Field Instructors

Student Activity Guide

Case of the Disappearing Log

After exploring the "Case of the Disappearing Log," students will probably never look at a log the same way again. In this activity, students assume the roles of detectives faced with a nature mystery. First, they explore a decomposing log and look for evidence of how the log is changing. They make possible explanations for what might be causing log to disappear. Students then learn about common "suspects"—organisms that decompose wood—and the signature evidence they each leave behind. Students use a *Disappearing Log Key* to identify which organisms might have left behind which evidence, and use this information to make explanations about what has happened to the log since it was a tree. Finally students learn that the log isn't really disappearing, it's turning into the invisible gases that are part of the cycling of matter in all ecosystems.

Students will...

- **Explore fallen logs and find evidence for various impacts upon them.**
- **Learn information about log decomposers from Suspect & Evidence cards.**
- **Use a key to identify evidence of different organisms and other impacts on logs.**
- **Use observation and reasoning to make explanations about what has happened to the log, including a possible sequence of events.**

Grade Level:
Grades 4-8. Adaptable for younger or older students.

Timing:
about 60 minutes, (70 including optional section)

Related Activities:
Notice, I Wonder, It Reminds Me Of
NSI: Nature Scene Investigators
Bark Beetle Exploration
Tracking
Decomposition Mission

Materials:
For instructor:
1 portable whiteboard/marker
(optional) Evidence and Suspect Cards (page 16), cut apart
For every 3-4 or pairs of students:
1 Disappearing Log Key (page 22)

Tips:
To ensure a successful experience, review the teaching tips found on page 9 and throughout this guide.

Setting:
You need one large & mysterious decomposing log for the beginning, then ideally another large one or enough logs for each team of 3-4 in a different location.

NEXT GENERATION SCIENCE STANDARDS

For additional information about NGSS, see page 11 of this guide.

FEATURED PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Constructing Explanations	Cause and Effect	Interdependent Relationships in Ecosystems

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Case of the Disappearing Log

ACTIVITY OVERVIEW

Case of the Disappearing Log	Learning Cycle Stages	Estimated Time
Introducing the Activity	Invitation	5 minutes
Initial Explorations	Invitation, Exploration	5–10 minutes
Initial Sharing	Concept Invention	10 minutes
Optional — Meet the Suspects	Concept Invention	(15 minutes)
Investigating With a Key	Concept Invention, Application	25 minutes
Wrapping Up	Reflection	10 + minutes
TOTAL		~ 60 (75) minutes

TEACHING TIPS

Field Card. On page 14 of this guide, you'll find a condensed, pocket-sized version of the activity you can carry with you in the field.

Read the Instructor Support Section. Beginning on page 9, you'll find more information about pedagogy, student misconceptions, science background, and standards.

Choosing a dynamic log. It's ideal to begin this activity with a big, mysterious log the group can investigate together. After that you can continue with the same log, move on to a different large log, or to an area with enough interesting logs for each team of 3–4 to have their own to investigate. Logs with a variety of kinds of decomposers are ideal. A log that has fallen and is a little distance from its stump or has broken into different parts is a fun mystery to try to explain.

Moving between "chunks" of the activity. If your group needs to be more active and there are abundant decomposing logs, you can move the group to a different location after the initial exploration.

Optional: Meet the Suspects. See the sidebar on page 4 to help you decide whether or not to do this activity with cards. If you do choose to use them, make 1 suspect card or evidence card for each student. For additional logistics information, see the introduction text next on page 16.

All materials created by BEETLES™ at The Lawrence Hall of Science.
Find the latest activities and information at http://beetlesproject.org.

Introducing the Activity

1. **Students play "step into the circle if" about solving mysteries.** Gather students in a circle. Ask them to take a step into the circle if the statement applies to them, then step back out. Tell them to do this after each of the following statements—IF:
   - You've ever watched a detective show or movie.
   - You've heard of Sherlock Holmes.
   - You've ever lost something and tried to figure out where it went.
   - You've heard the word "evidence" [ask them to define it].
   - You know what a "suspect" is [ask them to define it].
   - You've ever tried to figure out a mystery [ask a few to share].
2. **Explain that they'll be trying to explain a nature mystery.** Tell students they'll be acting as **detectives** today, trying to explain a nature mystery based on the evidence they find. Build suspense and pique their interest.
3. **Move to the decomposing log, & unveil the mystery—"*The Case of the Disappearing Log.*"** Explain that the log everyone is standing next to used to be a tree, and that people have been noticing that it, and other logs in the area, are slowly *disappearing*. Tell students that it will be their job to figure out what's happening to the log.

Initial Explorations

1. **Explain that they'll explore and observe the log together, looking for evidence that the log is disappearing.** Let students know they'll all be exploring and observing this log at the same time, trying to learn more about the ways the log is changing and disappearing. Ask students to discuss their observations with each other as they explore. If the group has hand lenses, make sure they use them to look up close, and understand where to hold the lens so the log will be in focus.
2. **While students explore, model & encourage making observations & asking questions—fan the flames of "inquiry fever."** As needed, model making some observations and saying them out loud as "I notice" statements. Ask questions to encourage students to observe the log in different ways and to help them focus in on different aspects and parts (texture, smell, holes, top, branches, roots, edges, etc.).
3. **If students are "stuck" or losing interest, suggest that they change their perspective.** If students get "stuck," suggest that they try other perspectives, such as looking at a different part of the log, getting down low and looking closely, or looking under the bark.

Initial Sharing

1. **Bring the group back together & tell students to share observations & evidence in pairs.** After ~10 minutes, but *well before* interest begins to wane, call for the group's attention and ask students to find a partner and stand in pairs around (or near) the log. Then, ask them to talk with their

TEACHING NOTES

Considering language. To increase the aura of mystery you might want to use words like "motive," "suspect," or "scene of the crime," when referencing decomposers and the log. If you do, make sure students understand that organisms don't actually commit crimes against each other or have "motives" like humans. Emphasize that organisms are merely acting for their own survival.

How and when to introduce "decomposition." When you first ask students to explore the log, they might say, "decomposers are making the log disappear," especially if they're familiar with decomposition as a process for breaking things down. If a student brings up this idea, you can go ahead and introduce a definition and ask for evidence. But try to focus students on exploring and observing the log–that's how they'll actually develop their understanding of decomposition as a process that produces these results. It's a useful learning opportunity for students to relate what they observe during the activity to the process of decomposition. You can focus them back on decomposition towards the end.

Creating Inquiry Fever. What we call "Inquiry fever" happens when a group of students is enthusiastically investigating nature, building off each other's discoveries, ideas, and excitement. The 3 necessary ingredients for inquiry fever are: *having inquiry mindset and skills; permission and encouragement to explore; and interesting stuff or ideas to investigate.*

partner, to compare observations they made, and share any evidence they found that the log is changing or disappearing.

2. **Ask a few students to share their observations with the whole group.**

   ▶ *Describe what you noticed. What evidence did you find of the log disappearing? [They may say: holes, tunnels, crumbling wood, fungus, missing wood, etc.]*

3. **Encourage students to use hand signals to increase participation; pump up enthusiasm about ideas & questions.** When a student shares an idea, ask others who had the same observation, question, or idea to show this by raising a hand, putting a hand on their head, etc. Restate what a student says to make sure others understand. Use this time to help excite the group about sharing their ideas, and investigating questions or learning more about patterns that others have brought up. For example:

   ▶ *Wow, look how many of us noticed all those round holes! Justin wondered if there might be holes like that on other logs. Let's remember that question so we can check it out later.*

4. **Help students make connections between cause & effect when discussing evidence of the disappearing log.** As students point out holes, sawdust, or frass, tell them these are the *effects* that are *caused* by something in the natural world.

5. **Ask students to *Turn & Talk* about possible explanations for what might have caused the evidence they observed.** Tell them to think about the connection between cause and effect when they are sharing their explanations.

6. **Ask a few students to share out explanations.** Listen to their explanations, ask for evidence. Try to point out connections they are making between cause and effect.

Optional — Meet the Suspects

1. **Give each student either an "Evidence"or a "Suspect" card.** Explain that the *Suspect* cards have pictures and information about organisms that impact logs. The *Evidence* cards have pictures of evidence left behind by those suspects. The Evidence cards have more text on them, so you might want to give Suspect cards to students who may struggle with reading the text.

2. **Tell Evidence card holders to stay put, while Suspect card holders move around looking for a match.** Suspect card holders read the back of their cards to become familiar with the evidence they need to find. Then they walk up to each Evidence card holder and look at their cards until they find a match. For example, the student holding the Termite suspect card reads that termites make rough and ragged tunnels with dirt and wood particles in them. He circulates among the Evidence card holders until he finds a student with a picture of tunnels with dirt and wood particles. He then tells that student he thinks they're a pair, and they'll read the back of the card together to corroborate that the picture is of a "termite

TEACHING NOTES

Making observations vs. explanations. During this phase of the activity, students may be tempted to immediately share explanations instead of observations. For example, a student might say "my observation is that woodpeckers made holes in the log." Use the opportunity to point out the difference between observations and explanations by saying "so, your observation is that there are holes in the log, and your explanation is that the holes might have been made by woodpeckers?" If you make this point the first time a student shares an explanation, and continue to reframe students' statements throughout the day, they'll eventually learn to make this important distinction on their own.

Choosing whether or not to use "Meet the Suspects." This optional matching activity provides students with an opportunity to become familiar with organisms/processes that cause certain features of decomposition BEFORE they actually use the key. This can help them use the key more accurately to make explanations about the log. The reason it's optional is so you can decide whether or not your students are able to use the key without this preparatory piece. You might also consider skipping this section if your students are having trouble focusing and need to be a little more active. Note that there are two sets of "suspect" cards: one for older students, with additional information about the order in which these factors impact decomposing logs (this can be useful for creating possible explanations for what has happened to the log since it was a tree). The other set of cards is more suited for younger students.

tunnel."

3. **Once pairs have found each other, tell them they should share their cards out loud with each other.** Pairs read out loud the information and images on their cards to become more familiar with their suspect and the evidence they leave behind.

4. **As students try to match suspects with evidence, circulate & support those who might be struggling.**

5. **Matched pairs mingle & introduce themselves to other evidence/suspect pairs.** Explain that students should stay with their partners and introduce themselves as a unit. When meeting another pair, they **hold their cards up** so the other pair can see the pictures. During the introduction, they explain who they are, e.g., "I am a carpenter ant. I make smooth and finished tunnels straight through wood." "I am a carpenter ant tunnel. This is what I look like." Circulate during the Meet and Greet to make sure all pairs are sharing their pictures and information.

Investigating with a Key

1. **Tell students they'll learn more about the possible causes of the evidence they found.**

2. **Explain that they'll use a key to identify suspects & connect them with the evidence.** Explain that the different signs they found on and in the log are evidence of certain suspects digging, eating, and living in the log. (If students have come up with these concepts themselves during the group sharing, refer back to this discussion.) Let them know they'll get to use a tool called a ***key*** to help them use evidence to figure out "whodunnit."

3. **Demonstrate how to use the *Disappearing Log Key*.** Carefully walk students through each step, going from top to bottom, for a piece of evidence on the key. Talk through one example: If they found tunnels that are pretty rough and have some mud in them, they'd go to the "tunnel" section and follow the arrows to try to decide which matches better (1) clean, straight tunnels, smooth-edged, or (2) rough and ragged tunnels with dirt & wood particles inside (the latter). Then show them how to follow the arrow down to the most likely suspect, in this case—termites. Make sure students realize the key is double-sided.

4. **Students use the key while working in teams to figure out which suspects caused the evidence on the log.** Either bring the whole group to another large log, or tell each team to choose their own log in an area you've designated, with a few decomposing logs near each other. Tell them they'll work in teams (of 2, 3, or 4) to try to explain the mystery of the disappearing log. Encourage them to try to find evidence of the log changing or disappearing, and to identify as many suspects as they can that could be responsible for the evidence they find.

5. **Encourage students to look for evidence of where the tree stood, make possible explanations for how it fell, & the order of suspects & events that impacted the log.** In addition to identifying suspects, encourage

TEACHING NOTES

Keeping Students Engaged. One of the main goals of this activity is to get students interested in exploration. If any part of the activity (a particular discussion question, a stage of exploration etc.) seems to drag at all, feel free to move on to a different question or phase of exploration.

More on brown & white rot fungi. If students seem interested, you might want to share that brown rot fungus consumes the white parts in wood, leaving the cubic brown stuff behind. White rot fungus consumes the brown parts and leaves the whitish parts behind. (See Instructor Support for more on this.) In the key, images of fruiting bodies of brown rot fungus and white rot fungus are included so students can see an example of this type of organism. But there are many different fungi that cause these kinds of rotting patterns. Help students understand this by pointing out that there are some bracket fungi that cause brown rot, and other kinds of bracket fungi that cause white rot.

TEACHING NOTES

An example of using Suspect cards to make a detailed timeline of events for the decomposing log. From the cards, students might learn these facts: fungi often enter where bark has been damaged, boring beetles usually go for weakened trees, and woodpeckers drill for insects in wood. They can use this information to create a scenario where first the bark was damaged by humans or other bark-stripping organisms, then the fungus invaded the damaged bark, and weakened the tree. Then the boring beetles could have swarmed the tree, and woodpeckers may have drilled holes to catch the beetles. Finally the tree died and fell.

On being a co-investigator with students. It's engaging to investigate a real nature mystery. Even if you've investigated the same log with students multiple times, you can't know exactly what happened, and there's always more to discover and think about. Make sure you act as a co-investigator, valuing their ideas without trying to lead them to a particular answer. If they get the sense that you have an answer you're trying to arrive at, then the mystery will feel false, and students may be reluctant to share ideas. As a co-investigator/instructor, do share some of your ideas and contribute additional information, using appropriate language of uncertainty and citing your sources, *but do so judiciously.* It's most empowering for students to find out information for themselves, and to go through the process of evaluating and discussing their own evidence and explanations.

students to look for evidence in the area of where the tree stood, what could have caused it to fall down, and to try to come up with the order of events.

6. ***For older students only:*** **Pass out sheets of suspects, and explain how this information can be helpful in explaining a possible order of events.** Pass out full sheets of the suspect cards to each team. Explain how they can learn more information about exactly how things may have happened by reading these details.

7. **Circulate, troubleshoot, be a co-investigator, and ask questions.** Help out students who might be struggling with finding evidence, using the key, or making explanations. Encourage students to carefully identify as many suspects as they can. Leave enough time for students to find examples of evidence caused by a variety of suspects, and to come up with possible explanations for the order of events.

Discussing Explanations

1. **Gather the group & ask each team to share their explanations with another team.** Encourage students to talk about their evidence as they share their explanations. If they came up with different explanations, ask them to disagree respectfully. Listen in on some of their discussions so you can refer to their ideas during the following discussion.

2. **Ask a few volunteers to tell the whole group their explanations & the sequence of what happened to the log, using language of uncertainty.** Remind students that they don't know what actually happened, so it's important to use language of uncertainty when sharing their explanations. Offer some examples of phrases they can use, such as: "we think maybe..." or "the evidence seems to show that..."

3. **Encourage respectful disagreement & ask for alternative explanations.** Ask students to agree or disagree respectfully with each others' explanations, and to try to discuss alternative explanations.

4. **Focus the discussion on the relationship between the suspects and the environment of the log.** Ask:

   - *How many different organisms can you think of that might have benefited from the tree/log you investigated?*
   - *What do organisms that are breaking down the log get from the log?*

5. **Point out that scientists have conversations like this to come up with the best explanations.** Explain that scientists need to think critically about any proposed explanation, and be open to new ideas, in order to decide which is the most useful and accurate explanation.

   - *The point of science is to come up with explanations based on all available testable evidence. Scientists need to be open to different explanations, and to think critically about each explanation.*

6. **Describe how thinking about cause & effect relationships helps us**

understand what has happened by developing possible explanations.

- *Just like scientists, you observed evidence of what has happened, then made possible explanations for what caused the effects you observed.*
- *Scientists use the idea of cause and effect to make explanations in all areas of science.*

Wrapping Up the Case - Reflection

1. **Return students' focus to the "Case of the Disappearing Log."** Remind them that you started this activity by introducing the "case of the disappearing log" because people had noticed that the log was slowly disappearing. It's true that when you compare logs on the ground to trees that are growing, it looks like some stuff they're made of–matter–has been lost.

   - *What happened to the rest of the matter in the log? Where is the missing wood now? Where could it have gone? [Students may say: decomposers ate it; it turned into poop; it washed away]*

2. **Suggest that some things that happen in nature don't always leave behind observable evidence.** They observed lots of evidence for the suspects and decomposers that caused the visible changes in the log, so they can account for some of the wood that was lost in that way. But there are also processes going on in the log that they can't observe directly–things that are invisible to the naked eye.

3. **Briefly discuss what decomposers do with matter from the log.** Explain that decomposers eat the wood, turning some of the matter into the structures of their bodies, and releasing some matter as wastes. We can see evidence of matter used by decomposers in their solid and liquid wastes—but we can't see the **gases** they release!

4. **Reveal that the matter in the log didn't actually disappear—it just changed its form.** You can now tell students that the log isn't really "disappearing," it's just turning into another form of matter–invisible gas.

   - *Scientists know that matter can't be destroyed, or disappear into nothing.*
   - *We do know that matter can change its form—going between solid, liquid, and gas—and that gases can be invisible.*

5. **Explain where the matter goes.** Tell students some matter from the log becomes part of the soil and the decomposer's bodies, but most of the matter is released as the gases CO_2 & H_2O as decomposers release these wastes into the air. These invisible gases are essential for all ecosystems. They could be absorbed by other plants and become part of other logs. There's matter cycling around in this ecosystem, and some of it's invisible!

6. **Tell students to keep looking at other wood in the forest for more mysteries & evidence.** After an experience like this, it's natural for kids to start spotting holes in and other features in wood everywhere, pointing them out to each other and talking about what may have caused them.

TEACHING NOTES

On the role of decomposers. If students say, "they're decomposing the wood because that's their role." Point out that decomposers don't *know* they are decomposing, and don't care that people have categorized them as decomposers. These organisms don't do what they do because they *want* to break down the wood and tidy up the forest, so they can contribute to the ecosystem like good little responsible decomposers. Decomposers do what they do in order to survive and reproduce. And survival sometimes includes busting out of their decomposer role and eating living things, too!

TEACHING NOTES

Keep the keys and cards handy, so students can refer to them when they become curious about other decomposing wood during their field experience. Encourage them to try to figure out the causes for the effects they see.

- *Cause & effect is a useful way to think about any mysteries. What are some other nature mysteries we can use "cause & effect" to try to figure out what happened?*

7. Use the following reflection questions for whole group discussion or while walking in pairs using *Walk & Talk*:

See BEETLES activity *Walk & Talk* for logistics of this routine.

- *What are some questions you have about decomposing logs & the organisms that decompose them?*
- *What other evidence would you like to have to explain this mystery?*
- *What helped you to learn today? How might you share what you learned with someone like a family member?*

8. More *Walk & Talk* application questions. Tell students to imagine they're back at home and their family is worried the house has some kind of infestation/the wood seems to be decaying. Ask students to discuss with a partner:

- *How could you tell if the wood is decomposing?*
- *What evidence would you look for to figure out the causes of the effects you're seeing?*
- *Why might the organisms be in the wood in your house?*

Related science profession: historical ecologist. Students might suggest that it would be useful to have photographs, or to talk to people who have been on the land for a long time, to get more evidence to explain what happened. Historical ecologists collect evidence about the interactions between humans and their environment. They attempt to piece together what the landscape has been like over long periods of time, and what has caused changes over time. As evidence for their explanations, they use observations, organism surveys, historical photographs, and live and ethnographic interviews with people who have lived in the area.

Instructor Support

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Teaching Knowledge

Exploration leads to curiosity. The initial exploration of the log is essential for piquing student interest. If you plunge straight into the content of suspects and evidence, you're skipping the phase where students touch, feel, smell, and wonder about the fallen log. They need to become curious, start to invest in the mystery, and develop a real desire to try to explain it. This exploration primes students for the more detailed investigation with the *Disappearing Log Key* that comes later.

Multiple exposures make for stickier learning. It's hard to hold onto information you only receive once. It's also hard to start applying knowledge before you've acquired it! That's why we have the *Meet the Suspects* stage of this activity. In that stage, students are exposed to the images and labels that are on the *Disappearing Log Key,* and in the more advanced version, information about the suspects. Meeting with all the other pairs allows students to become familiar with the suspects before they attempt to connect them to evidence on the logs. Each pair will become especially familiar with one suspect, the one whose cards they're holding.

Connecting explanations to evidence. Sometimes students jump to conclusions, or make elaborate explanations based on pretty flimsy evidence. "That scrape on the bark was made by a bear!" Help them stay open-minded, and use language of appropriate uncertainty. You can also help them evaluate their own evidence and explanations, by encouraging them to defend their claims with evidence. For instance, if a student says, "I think a woodpecker made these holes," ask questions such as: What's your evidence for that? What makes you think that? What size are the holes? What other organisms make holes that size or shape? Do you think the holes were made while the tree was alive or dead?

Larger assumptions make weaker evidence. It can also be helpful to focus students on evaluating their explanations based on the size of their logical assumptions. For example, if you find actual termites on a decomposing log, the size of the assumption you have to make about termites being part of the decomposition process is very small, which means it's pretty strong evidence. But if you see ragged tunnels on the log, it may be evidence of some termites, but the size of the assumption you'd have to make is a little larger. So seeing tunnels that look like termite tunnels is weaker evidence than seeing the termites themselves. And seeing a termite wing near a fallen log involves making an even larger assumption about its role in decomposition, therefore, this is evidence, but weaker evidence for your explanation.

Conceptual Knowledge

Fallen logs were once standing trees! As you explore fallen logs, try to help students imagine what they were like as living trees. Search for evidence to the following questions: How long ago did the tree fall? Where was the tree growing? Can you tell which part of the log was closer to the roots and which was closer to the top? Was the tree cut by humans or did it fall on its own and

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then get chopped into logs? Which suspects might have impacted the tree while it was still alive? Which suspects may have arrived after the tree fell?

Not all suspects are on the key. Depending on your location, you may find evidence of suspects that are not on the key, and students may misidentify them thinking that they are all on the key. There are many species of fungi, for instance, and this small key could not include them all. Don't discount any evidence students find; encourage them to observe closely and make explanations even if they don't know the suspect's name. And help them be OK with not knowing for sure what caused some feature, and encourage them to try to figure those out through reasoning.

Some organisms pave the way for others. Scientists have studied the succession (order) of decomposition for a lot of different wood types. Sometimes there is a predictable pattern in which species colonize the tree. For example, many species of fungus will begin growing on a tree while it's still alive. Woodpeckers often create holes in already-hollow trees that have been weakened by fire or fungus. Their drilling, in turn, may make the tree more vulnerable to disease or infestation of insects. Eventually, under pressure from multiple sources, the tree dies. Once it dies, new organisms arrive. As the tree decays more and more, the wood becomes digestible to even more species of decomposers. Here's another example of decomposition succession: Certain species of bark beetles known as "ambrosia beetles" carry fungal spores in their bodies and inoculate trees with the fungus when they enter the bark. The fungus begins breaking down the surrounding wood, making it more digestible to the beetles and other decomposers as well.

The deal with brown rot and white rot. Both types of rot are caused by fungi. In fact, there are several types of fungi that cause each type of decay. The difference in appearance between brown rot and white rot has to do with the part of the plant cell that the fungus attacks. **Brown rot fungi attack the cellulose** of the wood and leave the lignin intact. Lignin makes up the secondary cell walls and it gives the wood stiffness and rigidity. When the lignin is left intact, the wood breaks down into rigid, cubic sections. The wood is brown because lignin is brown, hence the name "brown rot." **White rot fungi attack the lignin** of the wood and leave the cellulose behind. When the lignin decays, the wood loses its rigid structure and instead appears spongy, stringy, and soft. Without lignin's brown pigment, this wood appears whitish/yellowish, because that's the color of the unconsumed cellulose, hence the term "white rot."

Decomposers and living trees. Living trees are at risk of decomposer invasion, especially if their bark is damaged. Some fungi attack and weaken the wood of living trees. Many of these fungi are shelf-like and gain access to the tree through existing damage, including stubs (from broken branches) and scars (from removal of bark). Wood boring beetles also enter living trees through these damaged features. Wounds from beetles as well as holes made by woodpeckers also provide access for pathogens to infect the living tree. The death of a living tree is often caused by many components of the ecosystem interacting.

Importance of the idea that matter cycles. Decomposing logs are nicely

"Butt rot." It's fun to say, and it's an actual term used to describe a type of damage to trees caused by fungi. "Butt rot" is when fungi attack trees through their roots and decay the lower "butt" portion of the tree. This can weaken or sometimes hollow out the base of the tree.

Beetles and climate change. Particularly if you're in an area where infestations of beetles have been decimating forests, a discussion about the balance between populations of organisms can be valuable. Normally, bark and boring beetles attack weak trees, which is good for thinning forests. But warming temperatures in some areas have allowed these beetle populations to explode and attack whole forests of healthy trees, sometimes killing most or all the trees in one area. This can be a graphic local connection to the global issue of climate change for students. When these beetles are mentioned in the media, it's usually in connection with the devastation they cause, without presenting a well-rounded view of the balanced ecosystem. It's good for students to learn that bark and boring beetles can be part of healthy ecosystems when their populations are in the right balance.

accessible examples of how matter cycles. It should be noted that as the decomposers consume the wood, none of the matter actually "disappears," but it merely changes form. Some matter from the wood becomes part of the organism, and much ends up as wastes, in the form of nutrients and organic matter in the soil, as well as carbon dioxide and water released into the air. The amount of matter circulating in Earth's systems, (both living and non-living), including the atmosphere, is pretty much set. The exceptions are a tiny amount of air molecules being lost into space and any space debris that enters our atmosphere. For millennia, virtually the same matter particles have been cycling around and around on Earth. Please note that energy, on the other hand, "flows." The energy contained in food and other matter on Earth may be passing through some cycles, but energy is constantly lost at every step of the process. Energy flows into Earth's systems daily, and is lost into space daily (otherwise we'd have a really hot planet!). Decomposition is a great example of *matter* cycling, and is an important understanding related to the carbon cycle. Scientists' investigations (and students' too!) of these ideas are pivotal to reaching a better understanding of climate change issues.

Connections to *Next Generation Science Standards (NGSS)*

BEETLES student activities are designed to provide opportunities for the "three-dimensional" learning called for in the *NGSS*. To experience three-dimensional learning, students need to engage in practices to learn important science content (Disciplinary Core Ideas) and relate that content to big ideas in science (Crosscutting Concepts). In short, students should be exploring and investigating rich phenomena, trying to figure out how the natural world works. *Case of the Disappearing Log* engages students in the practice of *Constructing Explanations* to build some foundation for understanding disciplinary core ideas related to *Interdependent Relationships in Ecosystems*, and relate those ideas to the crosscutting concept of *Cause and Effect*

Featured Science and Engineering Practices

Engaging students in Constructing Explanations. According to *NRC's A Framework for K–12 Science Education*, a major goal of science is to deepen human understanding of the world through making explanations about how things work. It follows that students should develop their understanding of science concepts by making their own explanations about natural phenomena. In *Case of the Disappearing Log,* when students discuss what might have caused the log to change or "disappear," they're making tentative explanations. For example, a student who says, "I think that this sawdust-like stuff on the log is the poop of an insect" has generated a possible explanation for how the log is decomposing. In order for students to be fully engaged in the practice of constructing explanations, they need to go beyond just making explanations similar to the above. They also need to consciously use tentative language ("I think that..."), base their explanations on evidence, and consider alternate explanations based on that evidence. The part of the activity in which students discuss alternate explanations for what has happened to the log since it was a tree can deepen their experience with this practice. This discussion provides an important opportunity to coach students to include their evidence and reasoning when they give an explanation, and to entertain alternate explanations for the same phenomenon.

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About the *Next Generation Science Standards (NGSS)* The development of the *Next Generation Science Standards* followed closely on the movement to adopt nationwide English language arts and mathematics Common Core standards. In the case of the science standards, the National Research Council (NRC) first wrote a *Framework for K–12 Science Education* that beautifully describes an updated and comprehensive vision for proficiency in science across our nation. The *Framework*–validated by science researchers, educators and cognitive scientists–was then the basis for the development of the *NGSS*. As our understanding of how children learn has grown dramatically since the last science standards were published, the *NGSS* has pushed the science education community further towards engaging students in the practices used by scientists and engineers, and using the "big ideas" of science to actively learn about the natural world. Research shows that teaching science as a process of inquiry and explanation helps students form a deeper understanding of science concepts and better recognize how science applies to everyday life. In order to emphasize these important aspects of science, the *NGSS* are organized into three dimensions of learning: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas (DCIs). The DCIs are divided into four disciplines: Life Science (LS), Physical Science (PS), Earth and Space Science (ESS) and Engineering, Technology and Applied Science (ETS). Read more about the *Next Generation Science Standards* at http://www.nextgenscience.org/ and http://ngss.nsta.org/

NOTES

Importance of teaching science practices. "Engaging in the practices of science helps students understand how scientific knowledge develops...It can also pique students' curiosity, capture their interest, and motivate their continued study..." -National Research Council, *A Framework for K-12 Science Education*. Focus on these science practices will help to ensure a more scientifically literate public who will be better able to make thoughtful decisions.

About Crosscutting Concepts in the *NGSS*. Crosscutting concepts are considered powerful thinking tools for how scientists make sense of the natural world. The seven "big ideas" listed as crosscutting concepts are: Patterns; Cause & Effect; Scale, Proportion & Quantity; Systems and System Models; Energy & Matter: Flows, Cycles and Conservation; Structure & Function; and Stability & Change. These concepts may sound familiar, as they are quite similar to the themes referred to in science literacy documents as being important ideas that unify all disciplines of science and engineering.

Featured Crosscutting Concepts

Learning science through the lens of Cause and Effect. When scientists make explanations for how or why something happens, they are thinking about the connection between cause and effect. What we can observe of the natural world are "effects" of many possible "causes." Understanding relationships between cause and effect leads to a deeper understanding of the world, which is helpful in making predictions and explanations about what might happen in similar conditions in the future.

In *Case of the Disappearing Log,* students apply ideas of cause and effect as they examine the log and make possible explanations for what might be causing the features they observe (like holes, frass, etc.). Yet, students aren't introduced to the scientific application of "cause and effect" until the instructor explicitly points out that analyzing cause and effect relationships is an approach scientists also use when trying to decipher the mysteries of the natural world.

If students don't get the chance to consider how the idea of cause and effect connects to the explanations they're making, they miss the opportunity to recognize the idea of cause and effect as an important way of looking at the natural world. They also might not realize that the idea of cause and effect also applies in other scenarios, like making predictions about what might happen in the future, or explaining past events. Make sure to emphasize this with students, and to provide additional opportunities in their field experiences to apply the idea of cause and effect in different contexts.

Featured Disciplinary Core Ideas

Building a foundation for understanding Disciplinary Core Ideas. The *NGSS* make it clear that students need multiple learning experiences to build their understanding of disciplinary core ideas. *Case of the Disappearing Log* provides students with an opportunity to develop understanding of some disciplinary core ideas relating to LS2.A *Interdependent Relationships in Ecosystems* and LS2.B *Cycles of Matter and Energy Transfer in Ecosystems.*

When students observe features of a decomposing log, then use a key to identify the specific decomposers associated with certain features, they build understanding of the idea that organisms such as fungi and bacteria break down dead organisms, which recycles some materials to the soil for plants to use. Students also build understanding of how organisms depend on their interactions with living and non-living parts of their ecosystems (LS2.A). As they discuss where the matter in the log has gone, they build some understanding of how matter cycles between the air, soil, and among plants and microbes as those organisms live and die (LS2.B). Yet, students may not relate any of their observations and explanations to these DCIs if you don't take the time to explain where the matter in the log goes, and to point out to students that they've been exploring the process of decomposition. Don't miss this opportunity at the end of the activity, and continue to develop students' understanding of these ideas related to interdependent relationships in ecosystems by offering experiences through additional activities to deepen their comprehension of one or more of these concepts.

Performance Expectations to Work Toward

When examined closely, it's clear that the *NGSS* represent complex knowledge and multifaceted thinking abilities for students. No single activity can adequately prepare someone for an *NGSS* performance expectation. Performance expectations are examples of things students should be able to do, after engaging in multiple learning experiences or long-term instructional units, to demonstrate their understanding of important core ideas and science practices, as well as their ability to apply the crosscutting concepts. As such, they do not represent a "curriculum" to be taught to students. Below are some of the performance expectations that this activity can help students work toward:

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Activity Connections and Additional Ideas

Prepare students for curiosity about nature, close observation and scientific discourse with *I Notice, I Wonder, It Reminds Me Of,* and *NSI: Nature Scene Investigators*. For a similar but more focused activity in which students learn about the impacts of bark beetles, try *Bark Beetle Exploration*.

For a follow-up activity that allows students to develop detective skills on a more macro scale, try *Tracking*. *Decomposition Mission* is an activity that focuses on the role of decomposers, and could follow up this activity.

To continue to develop the practice of constructing explanations, use activities like *NSI: Nature Scene Investigators* or *Bark Beetle Exploration.*

For more activities that integrate the crosscutting concept of cause and effect, use *Bark Beetle Exploration* or *NSI: Nature Scene Investigators.*

To continue to develop student understanding of disciplinary core ideas related to interdependent relationships in ecosystems, use *Discovery Swap, Exploratory Investigation,* or *Bark Beetle Exploration.*

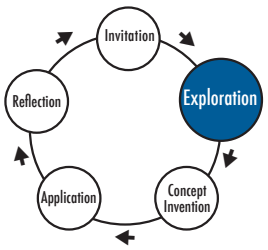
Other possible follow-up activities could include comparing logs in different ecosystems. If you have decomposing logs in significantly different ecosystems, students could compare them. For example, comparing a log in a dry and sunny grassland with a log in a moist and shady forest.

NOTES

Translating the codes for the *NGSS* performance expectations: Each standard in the *NGSS* is organized as a collection of performance expectations (PE) for a particular science topic. Each PE has a specific code, provided here so they can be easily referenced in the *NGSS* documents. The first number or initial refers to the grade level: K - kindergarten, 1 - first, 2 - second,etc...MS - middle school, and HS - high school. The next letters in the code refer to the science discipline for the standard: LS, PS, ESS, ETS. The number following the discipline denotes the specific core idea within the discipline that's addressed by the PE, and the last digit identifies the number of the PE itself.

So...5-LS2-1 means it's part of a fifth grade standard (5) for life science (LS), addressing the second core idea (2) *Ecosystems: Interactions, Energy and Dynamics*, within the life science standards. It's also the first performance expectation (1) that makes up the complete LS2 standard at this grade level.

Learning Cycle Stage for This Entire Activity as Part of an Extended Trail Experience



FIELD CARD

Cut out along outer lines, & fold along the centerline. This makes a handy reference card that will fit in your pocket.

Case of the Disappearing Log Field Card

Introducing the Activity

1. Students play "step into the circle if.." about solving mysteries. If:
   - You've ever watched a detective show or movie.
   - You've heard of Sherlock Holmes.
   - You've ever lost something and tried to figure out where it went.
   - You've heard the word "evidence" [ask them to define it].
   - You know what a "suspect" is [ask them to define it].
   - You've ever tried to figure out a mystery
2. Explain they'll be trying to explain a nature mystery.
3. Move to the decomposing log and unveil the mystery—*The Case of the Disappearing Log*

Initial Explorations

1. Explain that they'll explore and observe the log together, looking for evidence that the log is disappearing.
2. While students are exploring, model & encourage making observations and asking questions, & fan the flames of "inquiry fever."
3. If students are stuck, suggest that they change their perspective.

Initial Sharing

1. Gather group after 10 minutes, have students share observations and evidence in pairs.
2. Ask a few students to share their observations with the whole group.
   - *Describe what you noticed. What evidence did you find of the log disappearing?*
3. Encourage students to use hand signals to increase participation, & pump up enthusiasm about ideas & questions.
4. Help students make connections between cause & effect when discussing evidence of the disappearing log.
5. Students *Turn & Talk* about possible explanations for what caused the evidence they observed.
6. A few students share out explanations.

***Optional* — Meet the Suspects**

1. Give each student either an "Evidence" or a "Suspect" card.
2. Tell Evidence card holders to stay put, while Suspect card holders move around looking for a match.
3. Once pairs have found each other, tell them they should share their cards out loud with each other.
4. As students try to match suspects with evidence, circulate & support those who might be struggling.
5. Matched pairs mingle & introduce themselves to other evidence/suspect pairs.

Investigating with a Key

1. Tell students they'll learn more about the possible causes of the evidence they found.
2. Explain they will use a key to identify suspects & connect them with evidence.
3. Demonstrate how to use the *Disappearing Log Key*.
4. Students use the key working in teams to figure out which suspects caused the evidence on the log.
5. Encourage students to look for evidence of where the tree stood, how it fell, & the order of suspects & events that impacted the log.
6. Explain & pass out Suspect sheets (if you're using them).
7. Circulate, troubleshoot, be a co-investigator & ask questions.

Discussing Explanations

1. Gather the group, ask each team to share their explanations with another team.
2. Ask a few volunteers to tell the whole group their explanation and the sequence of what happened to the log; using language of uncertainty.
3. Encourage respectful disagreement and ask for alternate explanations.
4. Focus the discussion on the relationship between the suspects and the environment of the log.
   - *How many different organisms can you think of that might have benefited from the tree/log you investigated?*
   - *What do organisms that are breaking down the log get from the log?*
5. Point out that scientists have conversations like this to come up with the best explanations.
   - *The point of science is to come up with explanations based on all available testable evidence. Scientists need to be open to different explanations, and to think critically about each explanation.*
6. Describe how thinking about cause & effect relationships helps us understand what has happened by developing possible explanations.
   - *Just like scientists you observed evidence of what has happened, then made possible explanations for the effects you observed.*
   - *Scientists use the idea of cause & effect to make explanations in all areas of science.*

(continued on next page)

FIELD CARD CONTINUED

Cut out along outer lines, & fold along the centerline. This makes a handy reference card that will fit in your pocket.

Wrapping Up the Case — Reflection

1. Return student focus to the "Case of the Disappearing Log."
   - *What happened to the rest of the matter in the log? Where is the* missing wood now? *Where could it have gone?*
2. Suggest that some things that happen in nature don't always leave behind observable evidence.
3. Briefly discuss what decomposers do with matter from the log.
4. Reveal that the matter in the log didn't actually disappear— it just changed its form.
   - *Scientists know that matter can't be destroyed or disappear into nothing.*
   - *We do know that matter can change form—going between solid, liquid, & gas—and gases can be invisible.*
5. Explain where the matter goes: decomposers, soil, CO_2, H_2O.
6. Tell students to keep looking at other wood in the forest for more mysteries and evidence.
   - *Cause & effect is a useful way to think about any mysteries. What are some other nature mysteries we can use "cause & effect" to try to figure out what happened?*
7. Use the following reflection questions for whole group discussion or while walking in pairs using *Walk & Talk*:
   - *What are some questions you have about decomposing logs & the organisms that decompose them?*
   - *What other evidence would you like to have to explain this mystery?*
   - *What helped you learn today? How might you share what you learned with someone like a family member?*
8. More *Walk & Talk* application questions: Imagine your house may have an infestation.
   - *How could you tell if the wood is decomposing?*
   - *What evidence would you look for to figure out the causes of the effects you're seeing?*
   - *Why might the organisms be in the wood in the house?*

SUSPECT & EVIDENCE CARDS

How many cards do you need? There are 13 Suspect cards and 13 Evidence cards. If you have more than 26 students, you'll need to make some duplicates. If you have fewer than 23 students, you can either hand out more cards to students who finish early, or choose some cards to not hand out.

Don't recognize a suspect? If a suspect isn't common in your region, then don't hand out that card or its accompanying Evidence Card. That way students are less likely to be confused and "see" evidence of something that isn't there.

Older and younger students. There are two sets of Suspect Cards, one for older students and one for younger students. The set for younger students has shorter descriptions with more accessible language. The Evidence Cards are the same, regardless of which set of Suspect Cards you use.

Using the cards. Prints cards out, then cut along dotted lines. For more durability, print on card-stock or tape them to index cards.

Suspect Cards (for older students)

SUSPECT

I am a beaver. I chew around the base of trees until they fall over. I leave toothmarks low on trees. I use the trees to build dams to make pools. I eat bark, small trees, and other parts of plants.

SUSPECT

I am a deer, bear, squirrel, porcupine, mouse, rabbit, moose, or beaver. Sometimes I strip bark off of trees to eat it, eat insects under it, to eat sap, to make nests, to mark territory, or to scrape "velvet" off of antlers.

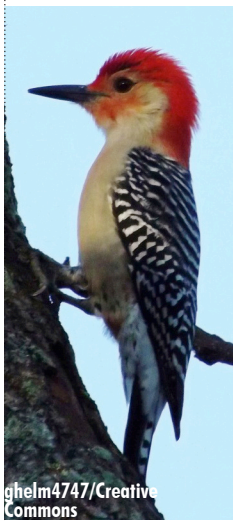
SUSPECT

I am a type of white rot fungus. I break down and consume the brown parts of cell walls. I leave behind the spongy, stringy, yellow & white cellulose in wood. I get into living or dead trees where bark has been damaged.

SUSPECT

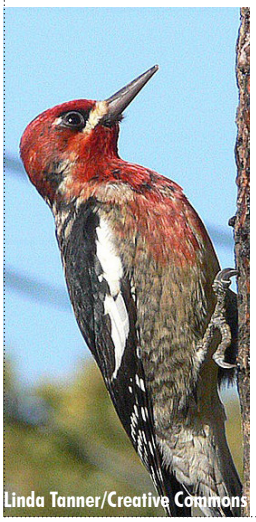
I am type of brown rot fungus. I break down and consume the white cellulose in wood. I leave behind the brown parts of cell walls (lignin) in brown cubic sections. I get into living or dead trees where bark has been damaged.

SUSPECT



I am a woodpecker, but not a sapsucker. I use my strong beak to dig holes larger than dimes in living or dead wood to catch insects, to stash acorns, and to make nests. I have a long, sticky tongue to pull insects out of holes.

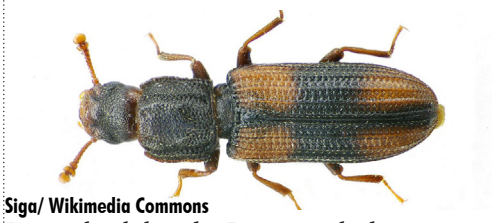
SUSPECT



I am a kind of woodpecker called a sapsucker. I make holes in living trees that are close together in rows and are smaller than dimes. I eat sap from the holes, and insects that get trapped in the sap. The holes I make can harm or kill trees.

SUSPECT CARDS (for older students) Continued

SUSPECT



Siga/ Wikimedia Commons

I am a bark beetle. I cut tiny holes through bark and live in the layer just under the bark (cambium). I lay eggs in smooth, shallow tunnels. My young carve tunnels away from where they were born. These tunnels look like designs. I mostly attack weak trees, and send out smells to signal other bark beetles to come to the

SUSPECT

K Schneider/ Creative Commons

I am a termite. I make rough and ragged tunnels for my colony to live in. I eat wood from dead or sick trees as I dig tunnels, and I leave dirt & wood particles in the tunnels. I build nests made of dirt, wood, and wastes. Sometimes I make tunnels of mud.

SUSPECT

Kevin Beals

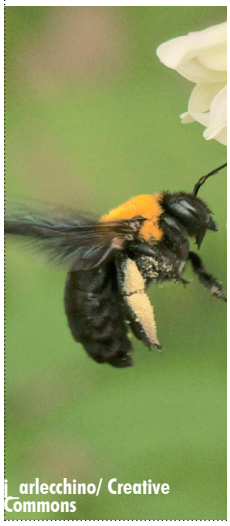
I am a carpenter ant. I make clean & smooth tunnels straight through wood for my colony to live in. I don't eat the wood, and I dump sawdust in piles outside the tunnels.

SUSPECT

Cody Hough/ Wikimedia Commons

I am a boring beetle. I bore (dig) holes that are small but deep, & not in rows. I spend most of my life living in wood. I come out when I'm an adult to mate and fly to make a new hole in wood. I usually bore in dead or sick trees, but sometimes I bore in healthy trees.

SUSPECT



arlecchino/ Creative Commons

I am a carpenter bee. I bore (dig) round holes barely smaller than a dime. I eat flower pollen, not wood. I usually live alone, or with my eggs. Males don't have stingers, and females rarely sting.

SUSPECT

H Dragon/ Creative Commons

I am fire. Sometimes people use me to burn a stump. Sometimes people cause wildfires that burn forests. Sometimes wildfires are caused by lightning. I leave black scars on the outside and inside of trees I burn. I turn wood into charcoal.

SUSPECT

H Dragon/ Creative Commons

I am a human being. I cut down trees to use lumber to build things, and leave stumps behind. Sometimes I damage tree bark by carving it. Sometimes I cut damaged branches to help a tree be healthy, or remove trees that may cause harm to people or other trees.

SUSPECT CARDS (for younger students)

SUSPECT

I am a beaver. I chew around the base of trees until they fall over. I leave toothmarks low on trees.

SUSPECT

I am a deer, bear, squirrel, porcupine, mouse, rabbit, moose or beaver. Sometimes we strip bark off of trees to eat it, eat insects under it, to eat sap, to make nests, to mark territory, or to scrape our antlers.

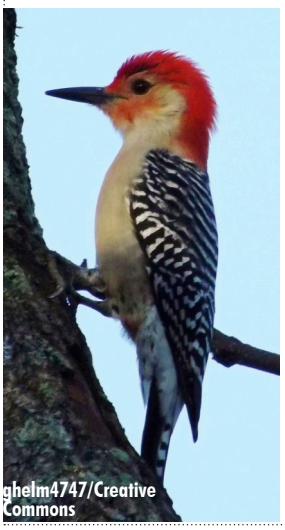
SUSPECT

I am a type of white rot fungus. I consume part of wood, and leave behind the spongy, stringy, yellow, & white cellulose in wood.

SUSPECT

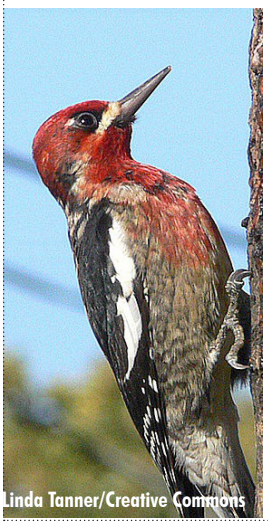
I am type of brown rot fungus. I consume part of wood, and leave behind the brown parts of wood in cubic sections.

SUSPECT



I am a kind of woodpecker, that is not a sapsucker. I use my strong beak to hammer holes larger than dimes in living or dead trees.

SUSPECT



I am a kind of woodpecker called a sapsucker. I make holes in living trees that are close together in rows and are smaller than dimes.

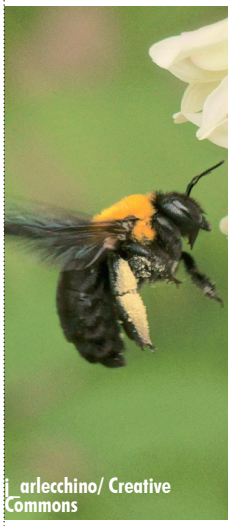
SUSPECT

I am fire. I leave black scars on the outside and inside of trees. I burn. I turn wood into charcoal. Sometimes people burn old wood on purpose. Sometimes, people start wildfires by accident. Sometimes, wildfires are caused by lightning.

SUSPECT

I am a human being. I cut down trees to use lumber to build things, and leave stumps behind. Sometimes I damage tree bark by carving it.

SUSPECT



I am a carpenter bee. I bore (dig) round holes in wood, barely smaller than a dime, where I live.

SUSPECT CARDS (for younger students) Continued

SUSPECT

Siga/ Wikimedia Commons

I am a bark beetle. I live just under the bark of trees, where I make smooth, shallow tunnels. My young are born there and tunnel away from where they were born. The tunnels look like designs.

SUSPECT

K Schneider/ Creative Commons

I am a termite. I make rough and ragged tunnels for my colony to live in. I leave dirt & wood particles in the tunnels.

SUSPECT

Kevin Beals

I am a carpenter ant. I make clean & smooth tunnels straight through wood for my colony to live in. I dump sawdust in piles outside the tunnels.

SUSPECT

Cody Hough/ Wikimedia Commons

I am a boring beetle. I bore (dig) small holes that go deep into the wood. I don't make tunnels in the layer of the tree that is just under the bark.

EVIDENCE CARDS

EVIDENCE

Bark Beetle Tunnels

EVIDENCE

Boring Beetle Holes

EVIDENCE

Carpenter Ant Tunnels

EVIDENCE

Stripped Bark

EVIDENCE

Burnt Wood

EVIDENCE

Beaver Chew Marks

EVIDENCE

Carpenter Bee Hole

EVIDENCE

Brown Rot

EVIDENCE

White Rot

EVIDENCE CARDS Continued

EVIDENCE

Sapsucker Holes
(a type of woodpecker)

EVIDENCE

Woodpecker Holes
(from a woodpecker other than a sapsucker)

EVIDENCE

Termite Tunnels

EVIDENCE

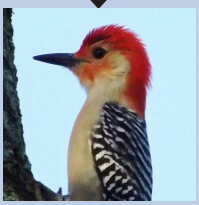
Stump

Decomposing Log Key

Holes

Holes bigger than a dime

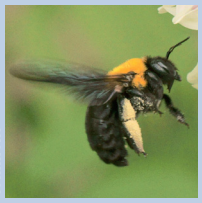
Woodpecker (other than sapsucker)



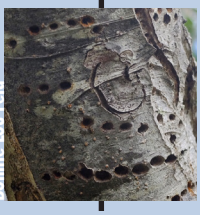
Holes smaller than a dime

round, barely smaller than a dime

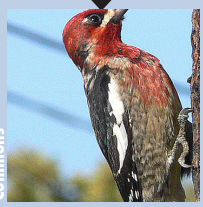
Carpenter Bee



close together in rows



Sapsucker (type of Woodpecker)

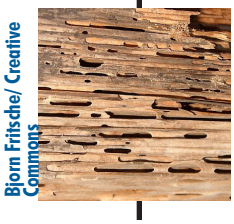


very small, deep, not in rows, round, D-shaped, or oval

Boring Beetle

Tunnels

Clean, straight tunnels, with smooth edges



Carpenter Ant

Smooth and shallow designs, just under the bark

Bark Beetle

Rough and ragged tunnels with dirt and wood bits inside

Termite

Crumbling Wood

Yellow or white, spongy or stringy wood

White Rot Fungus

Cubes of brown wood

Brown Rot Fungus

Burnt Wood

black bark or hollow tree

Mingo Hagen/Creative Commons

Forest Fire →

H Dragon/Creative Commons

Scraped Bark

scrape marks on tree

Ellen Macdonald/ Creative Commons

deer, bear, squirrel, porcupine, mouse, rabbit, moose or beaver →

Deer: glynn424/Creative Commons; **Beaver:** Needsmoreritalin/Wikimedia Commons; **Rabbit:** Thermos/ Wikimedia Commons

Chew Marks

tooth marks low on tree

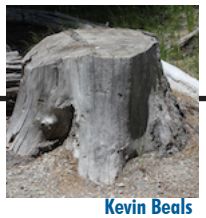
Gordon E. Robertson/ Creative Commons

Beaver →

Marie Hale/Creative Commons

Axe or Saw Marks

smooth slice of wood



Kevin Beals

Human Logging →

H Dragon/ Creative Commons

Look for evidence to help answer these questions to help you explain the mystery:

- Which suspects were involved?
- Where was the tree, and what made it fall?
- What was the order of events?

ABOUT BEETLES™

BEETLES™ (Better Environmental Education Teaching, Learning, and Expertise Sharing) is a program of The Lawrence Hall of Science at the University of California, Berkeley, that provides professional learning sessions, student activities, and supporting resources for outdoor science program leaders and their staff. The goal is to infuse outdoor science programs everywhere with research-based approaches and tools to science teaching and learning that help them continually improve their programs.

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