beetles
Science and Teaching for Field Instructors

Student Activity Guide

Case of the Disappearing Log

Case of the Disappearing Log offers learners an opportunity to investigate logs, trees, forests, and ecosystems through a lens of cause and effect and decomposition. In this activity, learners assume the role of "detectives" faced with a nature mystery. First, learners explore a decomposing log and look for evidence of how the log is changing. They make possible explanations for what might be causing the log to disappear. Learners then learn about organisms and forces that decompose wood and the signature evidence that is left behind. Learners 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, the instructor offers the idea that the log isn't really disappearing but is actually turning into the invisible gases that are part of the cycling of matter in all ecosystems.

Learners will:

- **Explore fallen logs and find evidence for how they are changing.**
- **Work together with peers in pairs and small groups.**
- **Use cause and effect as a thinking tool to engage in discussion and meaning-making.**
- **Learn information about log decomposers from Cause and 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 3–8. Adaptable for younger or older learners.

Timing:
65–85 minutes

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

Materials:
See the Materials and Preparation section on pages 3–4 for details.

Tips:
To ensure a successful experience, review the teaching tips found on page 2 and throughout this guide.

Setting:
An area with one large and mysterious decomposing log (or several large decomposed stumps) that learners can observe at the beginning of the activity and, ideally, another large log or several logs in a different location.

Equity, Inclusion, and Cultural Relevance (informed by Youth Outside)**:**
This activity has been designed to demonstrate how to create an equitable, inclusive, and culturally relevant teaching and learning experience. Read more, beginning on page 14.

NEXT GENERATION SCIENCE STANDARDS

For additional information about NGSS, go to page 16 of this guide.

FEATURED SCIENCE AND ENGINEERING PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Constructing Explanations	Cause and Effect	Interdependent Relationships in Ecosystems, Cycles of Matter and Energy Transfer in Ecosystems

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Case of the Disappearing Log

ACTIVITY OVERVIEW

Case of the Disappearing Log	Learning Cycle Stage	Estimated Time
Introducing the Activity	Invitation	5 minutes
Initial Explorations	Invitation, Exploration	10 minutes
Initial Sharing and Discussion	Concept Invention	10 minutes
Optional: Cause and Evidence Cards	Concept Invention	10–15 minutes
Exploring with a Key	Concept Invention, Application	15 minutes
Discussing Explanations	Concept Invention, Application	15 minutes
Wrapping Up and Reflecting	Reflection	10 minutes
TOTAL:		65–80 minutes

TEACHING TIPS

Read the Instructor Support section. Beginning on page 12, you'll find more information about pedagogy, science background, equity and inclusion, and standards.

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

Ideas about decomposition develop over time. It can take time to build understanding of a complex process such as decomposition. This is just one opportunity for learners to develop their understanding of these concepts. Ideally, lead this activity within a longer sequence of activities focused on concepts related to ecosystems and matter cycling.

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.

Field Card. At the end of this activity write-up, you'll find a condensed, pocket-sized version to use in the field.

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MATERIALS AND PREPARATION

MATERIALS

For the instructor

- portable whiteboard
- whiteboard marker

For each group of 3–4 learners or pair of learners

- 1 copy of Disappearing Log Key (pages 26–27)

For each learner

- optional: 1 Cause Card or 1 Evidence Card (pages 20–25)
- optional: 1 hand lens

PREPARATION

1. **Gather materials.**
2. **Find the area(s) where you will do the activity.** Find an area with one large and mysterious decomposing log (or several large decomposed stumps) that learners can observe at the beginning of the activity. For the second phase of the activity, it's ideal to find an area with another large log or several logs in a different location, so learners can apply their knowledge in a new context.
3. **Make copies of Disappearing Log Key (pages 26–27).** Make enough double-sided copies for each group of 3–4 learners or each pair of learners to share a copy.
4. **Decide whether or not to conduct the optional Cause and Evidence Cards phase of the activity.** This optional phase of the activity includes a matching-card activity. This offers learners an opportunity to become familiar with organisms and processes that cause certain features of decomposition BEFORE they actually use the Disappearing Log Key. This can support learners in accessing information in the key and offers more content that they can include as they make explanations about the log. You can decide not to include this preparatory step if you think your learners can jump right into using the key. Consider skipping this section in the moment if your learners are having trouble focusing and need to be more active.
    - **Cause and Evidence Cards (pages 20–25).** There are 2 sets of Cause Cards to choose from and 1 set of Evidence Cards. Each card set includes 13 cards. If you choose to do this part of the activity:
        - **Choose which set of Cause Cards to use.** One set is intended for older learners and includes additional information about the order in which the factors on the cards impact decomposing logs. (This can be useful for creating possible explanations for what has happened

TEACHING NOTES

TEACHING NOTES

Engaging directly with nature. Centering learning on learners' in-the-moment observations of organisms helps create an inclusive learning experience by focusing it on a shared experience to which every learner has access. This sets up a collaborative learning context in which learners' ideas and observations drive the learning experience, and learners recognize themselves and one another as sources of expertise. This is intentionally different from some other science learning situations in which participation requires prior knowledge, and learners who have had more exposure to science tend to have an advantage.

MATERIALS AND PREPARATION (continued)

to the log since it was a tree.) The other set of cards is more suited for younger learners. Consider your learners' literacy skills and access needs when deciding which set of cards will best meet their needs.

- **Make copies of each card set.** Make 1 copy of each card set so each learner can have either 1 Cause Card or 1 Evidence Card. Cut apart the cards. For more durability, make copies of the cards on cardstock or tape each card to an index card.
    - **Class size.** If you have more than 26 learners, you'll need to make some duplicates of the cards. (Each Cause Card has an accompanying Evidence Card, so make duplicates of a set). If you have fewer than 23 learners, you can either hand out more cards to learners who finish early or choose to not hand out some cards.
    - **Don't recognize a cause?** If a cause isn't common in your region, then don't hand out that Cause Card or its accompanying Evidence Card. That way, learners will be less likely to be confused and "see" evidence of something that isn't there.
    - **Cause Cards as a resource for older learners.** The Cause Cards for older learners include information on decomposition and the order in which different kinds of causes might impact a log. If you're working with older learners, consider making a few extra copies of the complete set of Cause Cards (no need to cut them apart) and offer them to learners when they're using the key to identify causes and make explanations for the sequence of events that impacted their log.

5. **Consider how you will tend to learners' physical comfort throughout the activity.** Being physically uncomfortable makes it more challenging to focus, make observations, and engage in a learning experience. Some suggestions for tending to learners' physical comfort include the following:
    - Give learners a clear picture of how long they will be outside, what kinds of activities they will be doing, and what kind of gear they might choose to bring to be comfortable in that setting.
    - Offer extra jackets or warm clothes that learners could choose to bring and wear during the field experience.
    - Offer frequent breaks for learners to move their bodies or eat a snack.
    - Check in regularly with individuals and with the group.
    - Be responsive to the group's needs, making adjustments as needed to support learners' comfort and engagement.

Introducing the Activity

1. **Invite learners to play "move into the circle if..." about solving mysteries.** Gather learners in a circle. Ask them to move or take a step into the circle if the statement applies to them and then move back out. Invite them to do this after each of the following statements—IF:

   - *You've ever lost something and tried to figure out where it went.*
   - *You have a favorite detective or scientist from a book, movie, story, or real life.*
   - *You've heard the word* evidence. *[Ask them to define it.]*
   - *You know what a cause is. [Ask them to define it.]*
   - *You've ever tried to figure out a mystery. [Ask a few to share.]*

2. **Share that learners will be acting as detectives today, trying to explain a nature mystery based on the evidence they find.** Build suspense, pique learners' interest, and invite them to get excited!

3. **Move to the decomposing log and unveil the mystery— Case of the Disappearing Log.** Share that the log that 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*. Encourage learners to consider it their job to figure out what's happening to the log.

Initial Explorations

1. **Share that learners will explore and observe the log together, looking for evidence that the log is disappearing.** Share that the whole group will have the opportunity to explore and observe this log at the same time, trying to learn more about the ways the log is changing and disappearing. Ask learners to discuss their observations with one another as they explore. If the group has hand lenses, encourage learners to use them to look up close. Offer support if learners need guidance in holding the hand lens so the log will be in focus.

2. **While learners explore, model and encourage making observations and 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 learners 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 learners are "stuck" or losing interest, invite them to observe the log from a different perspective or point of view.** Offer ideas for different ways that learners could make observations, such as observing a different part of the log, getting down low and looking closely, or looking under the bark. Invite learners to use their other senses; touch and smell can be interesting ways to observe the log. You can also invite learners to gently knock on different parts of the log and listen to what sound it makes.

TEACHING NOTES

Avoiding police-centric language. We encourage you to invite learners to act like nature detectives as they investigate the mystery of the disappearing log. Framing the activity as a mystery can be one way to encourage learners' excitement and engagement. At the same time, we discourage framing this activity as a crime or activity requiring policing, and we recommend avoiding language such as *motive*, *suspect*, or *scene of the crime* as it may be triggering for some learners.

How and when to introduce decomposition. When you first ask learners 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 down things. If a learner brings up this idea, you can go ahead and introduce a definition. After you introduce the definition, you can ask for evidence that might suggest that what learners are seeing is actually decomposition. At this stage of the activity, invite learners to focus on exploring and observing the log. This supports them in developing their understanding of decomposition as a process that produces the effects they can observe firsthand. Then, invite learners to return to the concept of decomposition again toward the end.

Creating inquiry fever. What we call Inquiry fever happens when a group of learners is enthusiastically investigating nature and building off one another's discoveries, ideas, and excitement. The three necessary ingredients for inquiry fever are: having an inquiry mindset and skills, permission and encouragement to explore, and interesting stuff or ideas to investigate.

Hand lens introduction. If you haven't done the activity *Hand Lens Introduction*, take the time to introduce the hand lenses as described in that activity (http://beetlesproject.org/resources/for-field-instructors/hand-lens-intro/).

TEACHING NOTES

Making observations vs explanations. During this phase of the activity, learners might share explanations in addition to observations. For example, a learner might say "My observation is that woodpeckers made holes in the log." Use the opportunity to invite learners to think about the difference between observations and explanations by saying, "Thanks for sharing your observation that there are holes in the log. The idea that woodpeckers made those holes is an explanation for the holes you noticed. Are there more possible explanations for how the holes could have gotten there?" Continue to highlight distinctions between observations and explanations throughout the learning experience.

Using signals to show agreement. When a learner shares an idea, invite those who had the same observation, question, or idea to show this by using a nonverbal symbol to show agreement. Come up with a signal for agreement that is within the abilities of all your learners. Possibilities could include moving or taking a step into the circle, raising a hand, using sign language, snapping, or another signal you and your learners come up with together.

Initial Sharing and Discussion

1. **Bring the group back together and ask learners to share observations and evidence in pairs.** After about 10 minutes but well before interest begins to wane, call for the group's attention and ask learners to find a partner and have a discussion comparing observations they made and sharing any evidence they found that the log is changing or disappearing.

2. **Invite a few learners to share their observations with the whole group and lead a short discussion about what they noticed.** Ask follow-up questions, encourage learners to build on one another's ideas, and follow learners' interest.

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

3. **As learners share their observations, encourage enthusiasm about ideas and questions and invite learners to use signals to show agreement and participate in the discussion.** Use this time to encourage learners to share their ideas, to follow learners' questions, and to make connections to what has been brought up. For example:

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

4. **Offer the idea of cause and effect as a thinking tool to use when discussing evidence of the disappearing log.** As learners point out holes, sawdust, or frass (insect poop), offer the idea that these are the *effects* that are *caused* by something in the natural world.

5. **Ask learners to *Turn & Share* about possible explanations for what might have caused the evidence they observed.** As learners share their explanations, invite them to think about specific forces or organisms that might have caused the evidence of the log disappearing.

6. **Invite a few learners to share their explanations with the group.** Listen to learners' explanations, ask for evidence, and make connections between the explanations learners share and the observations they made initially.

Optional: Cause and Evidence Cards

1. **Give each learner either 1 Cause Card or 1 Evidence Card.** Share that the Cause Cards have pictures and information about organisms and forces that impact logs, and the Evidence Cards have pictures of evidence left behind by those causes.

2. **Ask those with an Evidence Card to stay put, while those with a Cause Card should move around looking for a match.** Learners with Cause Cards will read their cards to become familiar with the evidence they need to find. Then, they will approach each learner with an Evidence Card and look at their cards until they find a match. For example, the learner holding the termite Cause Card reads that termites make rough and ragged tunnels with dirt and wood bits in them. That learner would circulate among those

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with Evidence Cards until they find a learner with a picture of tunnels with dirt and wood bits and then share that they think the two of them are a pair. The pair would then read the card together to confirm that the picture is of a termite tunnel.

3. **Share that once holders of matching Cause Cards and Evidence Cards have found one another, pairs should read their cards together.** Ask pairs to share the information and images on their cards to become more familiar with the forces and organisms that cause decomposition and the evidence that is left behind.

4. **As learners try to match causes with evidence, circulate, and offer support.**

5. **Matched pairs mingle and introduce themselves to other cause/evidence pairs.** After all learners have found their Cause/Evidence Card pairs, ask them to stay with their partners and introduce themselves to other pairs as a unit. Invite learners to share their cards when meeting another pair. For example, "This is a carpenter ant. They make smooth and finished tunnels straight through wood. This is a carpenter ant tunnel." Circulate to support pairs in sharing their cards and information.

Exploring with a Key

1. **Share that learners will now have a chance to learn more about what might be causing the log to disappear.**

2. **Share that learners will use a key to identify causes and connect them with the evidence.** Share that the different signs and observations learners found on and in the log are evidence of certain organisms digging, eating, and living in the log. (If learners came up with these concepts themselves during the group sharing, refer back to this discussion.) Let learners know that they'll get to use a tool called a key to help them use evidence to figure out the mystery of the disappearing log.

3. **Demonstrate how to use the Disappearing Log Key. Choose one piece of evidence and go to that section on the key. Carefully model moving through each part of that section (following the arrow from top to bottom or left to right, depending on the section you chose) to connect the evidence with a cause.** Make sure learners realize that the key is double-sided. Talk through one example:

   - *Let's say that we found tunnels that are pretty rough and have some mud in them.*
   - *We'd go to the Tunnels section and follow the arrows to try to decide which matches better: (1) clean, straight tunnels with smooth edges; (2) smooth and shallow designs just under the bark; or (3) rough and ragged tunnels with dirt and wood bits inside.*
   - *Okay, it looks like the rough and ragged tunnels with dirt and wood bits inside match our observations most.*
   - *Follow the arrow down to the most likely cause. In this case, it's termites.*

TEACHING NOTES

Choosing whether or not to use Cause and Evidence Cards. This optional matching activity offers learners an opportunity, before they use the Decomposing Log Key, to become familiar with organisms/processes that cause certain features of decomposition. For more information on deciding whether or not to include this phase of the activity, see the Materials and Preparation section, Preparation Step 4 (pages 3–4).

Keeping learners engaged. One of the main goals of this activity is to support and encourage learner interest in making observations and exploring the outdoors. If any part of the activity (a particular discussion question, a stage of exploration, etc.) seems to drag at all, move on to a different question or phase of exploration.

Be a co-explorer with learners. It's engaging to investigate a real nature mystery. Even if you've observed the same log with learners multiple times, you can't know *exactly* what happened, and there's always more to discover and think about. Act as a co-explorer, valuing learners' ideas without trying to lead them to a particular answer. If learners get the sense that you have an answer you're trying to arrive at, then the mystery could feel false, and learners may be reluctant to share ideas. As a co-explorer/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 often most exciting for learners to discover information for themselves and to go through the process of evaluating and discussing their own evidence and explanations. Playing the role of a co-explorer is one way to create an inclusive learning environment that de-centers the instructor as the sole expert and values the experiences and observations of learners.

TEACHING NOTES

More on brown and white rot fungi. If learners seem interested, consider sharing 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 the Instructor Support section, beginning on page 12, for more on this.) In the key, images of fruiting bodies of brown rot fungus and white rot fungus are included so learners can see an example of this type of organism. There are many different kinds of fungi that cause these kinds of rotting patterns, and you can share this idea with learners.

An example of using Cause Cards to make a detailed time line of events for the decomposing log. From the cards, learners 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. Learners could use this information to create an explanation that first, the bark was damaged by humans or other bark-stripping organisms. Next, 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.

4. **Invite learners to use the key while working in teams to figure out which causes left behind different kinds of evidence on the log.** Either bring the whole group to another large log, return to the original log, or invite each team to choose their own log in an area you've chosen that has a few decomposing logs near one another. Ask learners to form groups (of 2, 3, or 4) and work together to try to explain the mystery of the disappearing log. Encourage learners to try to find evidence of the log changing or disappearing and to identify as many causes as they can that could be connected to the evidence they find.

5. **Encourage learners to look for evidence of where the tree stood and to make possible explanations for how the tree fell and the order of causes and events that impacted the log.** In addition to identifying causes, encourage learners to look for evidence in the area where the tree stood, to think about what could have caused the tree to fall down, and to try to come up with the order of which causes might have impacted the tree first, second, last, etc.

6. **Optional: For older learners only: Distribute full sheets of Cause Cards and share that the information on the sheets can be helpful in explaining a possible order of events.** Distribute full sheets of the Cause Cards to each team. Share that the information about causes includes some ideas about when different organisms tend to eat, live in, or affect logs. Learners can use this information as evidence when making explanations about the order of events that impacted the tree.

7. **Circulate, offer support, be a co-investigator, and ask questions.** Offer support to learners as they find evidence, use the key, or make explanations. Encourage learners to carefully identify as many causes as they can. Leave enough time for learners to find examples of evidence created by a variety of causes and to come up with possible explanations for the order of events.

Discussing Explanations

1. **Gather the group and ask each team to share their explanations with another team.** Encourage learners to share their evidence as they share their explanations. If learners came up with different explanations, encourage them to listen to one another's ideas and reasoning. Listen in on some of their discussions so you can refer to their ideas during the following discussion.

2. **Invite a few groups of learners to share their explanations and the sequence of what happened to the log with the whole group, using language of uncertainty.** Share the idea that the group doesn't know what actually happened to the log, so it's important to use language of uncertainty when sharing their explanations. Offer some examples of phrases that learners can use, such as: "We think maybe..." or "The evidence seems to show that..." If learners make a statement that doesn't include the language of uncertainty, offer a reminder and invite them to rephrase their idea to include a phrase such as: "Maybe..." "I think that..."

or "Possibly..." To support your group in using this language, consider writing these phrases on a small sheet of poster board and holding it up during the discussion.

3. **Encourage respectful disagreement and ask for other possible explanations.** Ask learners to agree or disagree respectfully with one another's explanations and encourage them to share more possible explanations or different ideas.

4. **Focus the discussion on the relationship between the causes and the environment and ecosystem around 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. **Offer the idea that scientists engage in discussions with their peers to come up with the best explanations, like learners did.** Share that scientists think critically about any proposed explanation and strive to be open to new ideas in order to decide which is the most useful and accurate explanation.

   - *One goal 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.*
   - *Scientists have discussions and share ideas to try to find the best possible explanation, like we were just doing.*

6. **Invite learners to notice how thinking about cause-and-effect relationships can be used as a tool to understand what has happened and to develop 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 this idea of cause and effect to make explanations in all areas of science.*

7. **Return learners' focus to Case of the Disappearing Log and ask them to think about where the matter in the log has gone.** Remind learners that you started this activity by introducing 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.*
   - *Let's think back to the log we observed at the beginning of this activity. Where is the missing wood now? What happened to the rest of the matter—in other words, the "stuff" that the log is made of? Where could it have gone?* [Learners might say: decomposers ate it; it turned into poop; it washed away.]

   As learners respond, react to their ideas without immediately valuing them as right or wrong. Encourage multiple learners to share their ideas, agree/disagree with one another, and share their evidence before moving on.

TEACHING NOTES

On the role of decomposers. If learners say, "They're decomposing the wood because that's their job," offer the idea that ecosystems work because organisms take on different roles and that from the perspective of Western science, those organisms aren't necessarily taking on those roles in order to serve the ecosystem, but because that's how they've evolved.

Highlighting learning behaviors. Recognizing how learners' existing skills and learning behaviors mirror those of scientists can build their positive identities as learners. This can also offer learners a more accurate understanding of science as a discipline instead of a collection of facts. Calling attention to how learners' existing skills and in-the-moment learning behaviors are connected to what scientists do can highlight the fact that learners are already practicing science. This is one way to counteract exclusionary messages that learners may have received about what science is and who can do it.

Who is participating, who isn't? In a discussion, it's important for each learner to have the opportunity to be heard. However, research summarized in the book *Failing at Fairness: How Our Schools Cheat Girls* by Myra and David Sadker shows that girls are called on significantly less than boys. Promote equitable participation by using wait time, including time for pair talk, and intentionally calling on a range of different learners. Toward the end of a discussion, try pausing and saying, "I'm going to wait for a moment in case anyone who hasn't spoken up yet has something they'd like to share." Use the BEETLES activity *Group Agreements for Science Discussions* to offer your group of learners the skills to notice how their participation might be affecting the group and to enlist them in working together to create an environment in which everyone feels supported to share their ideas.

TEACHING NOTES

Insect flatulence. You might also choose to share that some of the matter from the tree has been expelled as flatulence by insects that ate it. This idea tends to be engaging for learners.

8. **Offer the idea that learners have been basing their explanations on things they can observe with their senses—like termite poop, holes, and tunnels—but that there are things going on that can be hard to detect with human senses.**

9. **Offer the idea that the matter in the log has changed into other types of matter, some of which can be observed, and some of which can't.**
   - *Scientists know that matter can't be destroyed or disappear into nothing.*
   - *The matter that is no longer part of the log has changed into other types of matter, some of which we can observe, and some we can't.*

10. **Review one or more ideas that learners have shared about where the matter from the log has gone, making connections to how each form of matter eventually becomes gases.**
    - *In our discussions, we've shared that some matter from the log is now insect poop or part of an insect's body, and we've found strong evidence for that.*
    - *What we **can't** see is that any insect that ate wood not only pooped out some of the matter but also **breathed** out matter, or "stuff" that used to be part of the log, as gases into the air, such as carbon dioxide and water. There is carbon dioxide and water in the air that used to be the log!*
    - *Another thing we can't see is that what is insect poop now will eventually be consumed by living things too tiny for us to see, like fungi and bacteria. Those fungi and bacteria will breathe out matter as air that was insect poop.*

11. **Invite learners to breathe in and consider where the air has come from.**
    - *Breathe in some air. Some of that air may have been part of this log or other logs.*
    - *The same is true of soil, crumbled wood, or [share examples that learners brought up earlier in the discussion], etc.*
    - *The matter from the log is now part of those things, and eventually all of it will become part of the air.*

12. **Share that other trees, plants, and algae breathe in gases and change them into plant matter.**
    - *Animals breathe in gases from the air, and so do trees and other producers. Plants and algae breathe in carbon dioxide and take in water, changing them into plant matter—like trees, which eventually become logs.*

13. **Share that the matter in the log didn't actually disappear—it just changed its form.** The log isn't really "disappearing," it's just turning into another form of matter—invisible gases.

14. **Offer the idea that invisible gases are essential for all ecosystems and that they could be absorbed by other plants and become part of other logs and other living things.**

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Wrapping Up and Reflecting

1. **Invite learners to keep looking at trees, logs, and other wood throughout the field experience and to keep looking for more mysteries and evidence of decomposition.**

2. **Throughout the field experience, invite learners to continue to think about how matter (some of it invisible) is cycling around in the ecosystem.** Now and then, throughout the rest of your field experience, consider inviting learners to apply this idea to other contexts. For example: "Where is that bush getting its matter from to grow?" Or: "What is the matter in this stick going to eventually change into?"

3. **Keep the keys and cards handy so learners can refer to them when they become curious about other decomposing wood during the rest of the field experience.** Encourage learners to try to figure out the causes for the effects they see.

4. **Invite learners to think about how cause and effect is a useful idea to use when approaching any mystery.**
   - *Are there other nature mysteries that we can use cause and effect to try to figure out?*

5. **Use the following reflection questions for a whole-group discussion or in a *Thought Swap* (formerly known as *Walk & Talk*):**
   - *What are some questions you have about decomposing logs and the organisms that decompose them?.*
   - *What other evidence would you like to have in order to explain this mystery?*
   - *What helped you to learn today?*
   - *How might you share what you learned with a family member or friend?*

6. **More *Thought Swap* application questions.** Have learners imagine that they're back at home, and their family is worried that the house has some kind of infestation/the wood seems to be decaying. Ask learners to discuss the following 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?*

TEACHING NOTES

Discussion routines. See the BEETLES activity *Thought Swap* (formerly known as *Walk & Talk*) or the BEETLES resource *Discussion Routines* for logistics on these discussion formats. Wondering why we changed the name from *Walk & Talk*? We received some feedback from our community partners on how we can use more inclusive language, and we decided to change the name so we were not normalizing walking as the only way of moving and talking as the only way of communicating.

Related science profession: historical ecologist. Learners might suggest that it would be useful to have photographs or 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.

TEACHING NOTES

Broad questions and science learning. Western science is often viewed or taught as a collection of facts; this is reinforced by science learning experiences that focus on memorization or recall of facts and narrow questions posed to learners that invite only one correct answer. However, science is a way of knowing and a process for thinking and learning, not just a body of knowledge. Including broad questions in science learning (questions that have multiple possible responses, such as "What might be the effect of putting pesticides in compost?") engages learners in scientific sense-making, encourages critical thinking, and makes space for divergent perspectives and differing ideas to be shared. Weaving broad questions throughout science lessons also sends the message that learners' ideas, lived experience, and creative thinking are an essential part of science learning, contradicting the exclusionary idea that memorizing facts or certain life experiences is what it means to be good at science.

Instructor Support

Teaching Knowledge

Exploration can lead to curiosity. The initial exploration of the log is essential and offers learners a common set of observations and experiences that ground the rest of the activity. If you plunge straight into sharing content about the causes and evidence of decomposition, you're skipping the phase where learners touch, feel, smell, and wonder about the fallen log. Offering learners the opportunity to become curious and engage in observation can support them to invest in the mystery and develop excitement to make explanations about what they've found. It also sets up an inviting tone of collaboration and teamwork and supports learners to engage in the detailed investigation with the Disappearing Log Key that comes later.

Supporting learner engagement: Multiple exposures make for stickier learning. The optional Cause and Evidence Cards phase of this activity offers learners the opportunity to study the images and labels they will encounter on the Disappearing Log Key. Meeting with all the other pairs allows learners to become familiar with the decomposers before they attempt to connect them to evidence on the logs and supports them as they access the information on the key. Each pair will become especially familiar with the cause on their card.

Connecting explanations to evidence. Creating evidence-based explanations is a set of skills everyone can learn and develop. If a learner shares an explanation that seems unlikely, such as: "That scrape on the bark was made by a bear!," invite them to stay open to multiple possible explanations and to use language of uncertainty (e.g. "I think…" "Maybe…"). You can also support learners to evaluate their own evidence and explanations by encouraging them to include evidence in their explanations. For instance, if a learner 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 encourage learners to evaluate 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. However, 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. Seeing a termite wing near a fallen log involves making an even larger assumption about its role in decomposition and, therefore, this is evidence, but weaker evidence for your explanation. The BEETLES classroom activity *Evaluating Evidence* offers opportunities for learners to build the skill of considering how the size of an assumption relates to the strength of evidence.

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Conceptual Knowledge

Fallen logs were once standing trees! As you explore fallen logs, invite learners to imagine what the logs 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 then get chopped into logs? Which causes or decomposers might have impacted the tree while it was still alive? Which decomposers may have arrived after the tree fell?*

Not all causes are on the Disappearing Log Key. Depending on your location, you may find evidence of causes or decomposers that are not on the key. There are many species of fungi, for instance, and this small key could not include them all. When you share the key with learners, clarify that they may not find everything on the key and that there may be causes or evidence that learners find that aren't on the key! Don't discount any evidence learners find; encourage them to observe closely and make explanations even if they don't know what caused a piece of evidence they're observing. Invite learners to be okay with not knowing for sure what caused some feature and encourage them to use reasoning and observations to figure out the mystery.

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 decompose the tree. For example, many species of fungus will begin growing on a tree while it's still alive. Woodpeckers often create holes in hollow trees that have been weakened by fire or fungus. Woodpeckers 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.

Brown rot fungi and white rot fungi. As wood rots, it usually changes form into one of two ways: brown, cube-like chunks (brown rot) or soft, beige, and more string-like parts (white rot). 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 term *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*.

TEACHING NOTES

TEACHING NOTES

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 in shape 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.

Matter cycles. Decomposing logs are accessible, observable examples of how matter cycles. As the decomposers consume the wood, none of the matter actually "disappears"—it changes form. Some matter from the wood becomes part of the organism that eats it, and much of the matter from the wood 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 nonliving), including the atmosphere, is more or less static. (The exceptions are a tiny amount of air molecules being lost into space and any space debris such as meteorites that enters our atmosphere). For millennia, virtually the same matter particles have been cycling around and around on Earth. 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 outer space daily (otherwise we'd have a really hot planet!). Decomposition is a great example of *matter cycling* and is an important concept that can support understanding of the carbon cycle. Scientists' investigations of these ideas (and learners' too!) are pivotal to reaching a better understanding of climate change.

Supporting Equitable, Inclusive, and Culturally Relevant Learning Experiences

This BEETLES student activity has been intentionally designed to create an equitable, inclusive, and culturally relevant learning experience for a community of learners. BEETLES design principles [http://beetlesproject.org/about/how-do-we-approach-teaching/] ensure that each activity is learner-centered and nature-centered. This enables all learners to access, participate, and engage in the learning experience.

When learners engage directly with nature, they all have access to learning, regardless of their prior knowledge or experiences. Centering learning on learners' in-the-moment observations of nature builds an inclusive learning experience by focusing the conversation on an experience shared by every learner, as opposed to relying on learners' prior knowledge or past experiences. As learners engage with nature, instructors are in the role of the "guide on the side." This approach shifts power from the instructor to learners, challenges the typical learning situation in which the instructor is the only expert, encourages learners to share their ideas and experiences, and makes learning a more decentralized and collaborative experience.

When learners think like a scientist and practice academic language, they develop critical thinking skills that support them to become more independent learners—learners who have skills and thinking tools they use to learn, regardless of the level of support available from a teacher or instructor. Giving learners the opportunity to think like a scientist by making observations, asking questions, and constructing explanations supports learners' growth as learners and offers them the opportunity to build critical thinking skills and learning behaviors they can apply in any context. Many learners in schools that have historically been under-resourced due to racist school funding policies, redlining, income inequality, and police profiling have fewer opportunities to develop as independent learners. Specifically ensuring that learners in these kinds of schools have opportunities to develop as independent learners is an issue of equity. Learning and practicing critical thinking skills in an engaging outdoor context supports learners to succeed back in their classrooms, in science, and in other academic disciplines. Offering opportunities for learners to discuss ideas with their peers and knowledgeable adults makes science more accessible by connecting it to learners' own actions and discoveries in the moment—not just to knowledge they may not have or experiences they may not have had.

Through discussion, learners make connections to prior knowledge, share their lived experiences, listen to different perspectives, and have time to process the material. Productive discussions in which many voices are heard, and the group builds off one another's ideas, create an experience in which learners see themselves and one another as sources of expertise. This ensures that instructors don't fall back on positioning themselves as the only source of accurate or important information. Participating in discussions also supports learners to develop cognitive rigor and the ability to take on more advanced learning tasks. Discussions make learners' thinking and ideas visible to the instructor. When instructors value, appreciate, better understand, and connect to learners' lived experiences, they create a more inclusive and culturally relevant learning space. Finally, multiple opportunities for discussion provide time and space for neurodiversity—allowing learners to process information in different ways. Using discussion strategies such as *Turn & Share* or *Thought Swap* (formerly known as *Walk & Talk*) that are part of every BEETLES student activity can help ensure that learners have these kinds of opportunities for discussion.

Specifically, *Case of the Disappearing Log* promotes an equitable, inclusive, and culturally relevant learning experience by:

- using broad questions to invite learners to share their observations, prior knowledge, perspectives, and experiences with one another and with the instructor.
- providing space for learners to come up with connections between what they are observing and prior experiences and knowledge, which supports their learning and retention.
- providing a simple key, and scaffolding to support learners in accessing the information on the key, regardless of prior knowledge or experience.

TEACHING NOTES

"Classroom studies document the fact that underserved English learners, poor students, and students of color routinely receive less instruction in higher-order skills development than other students." (Allington and McGill-Franzen, 1989; Darling-Hammond, 2001; Oakes, 2005) –Zaretta Hammond, *Culturally Responsive Teaching & the Brain*

TEACHING NOTES

Resources on unconscious bias. There are many great resources on understanding and shifting unconscious bias. Here are a few books and organizations we have looked to consistently to work on our own unconscious bias and to better understand how it can affect teaching and learning in the outdoors:

- *White Fragility : Why It's So Hard for White People to Talk About Racism* by Robin DiAngelo
- *Culturally Responsive Teaching & the Brain* by Zaretta Hammond
- Youth Outside [http://www.youthoutside.org/]
- The Avarna Group [https://theavarnagroup.com/]
- Center for Diversity & the Environment [https://www.cdeinspires.org/]

- engaging learners in meaning-making discussions that prepare them to take on increasingly rigorous learning tasks in the future.
- offering opportunities for learners to engage in NGSS Science and Engineering Practices such as *Constructing Explanations* that include transferable learning skills that learners can continue to apply in other academic disciplines and that support their development as independent learners.
- providing a lesson structure in which the instructor acts as a "guide on the side" and builds a collaborative learning environment in which learners make observations, share ideas, and see themselves and one another (not just the instructor) as sources of expertise.
- focusing the group's learning on a common experience to which everyone has access.
- providing learners with autonomy to explore what interests them, which increases engagement with the activity and further supports development of scientific habits of mind and general thinking skills.

Overall, these factors contribute to creating a learner-centered approach in which "the ultimate goal . . . is to help students take over the reins of their learning." (Zaretta Hammond, *Culturally Responsive Teaching & the Brain*, 2014). This approach to teaching supports learners in becoming independent learners who are able to succeed, regardless of any individual teacher or learning context. BEETLES has intentionally designed the sequence and structure of this activity to support learning experiences in which all learners feel capable of success and have the tools to carry that success into other domains.

Using learner-centered and nature-centered learning approaches is just one piece of the work we can do to create equitable, inclusive, and culturally relevant learning experiences. Instructors must also work to become more aware of their own unconscious biases and triggers around culture, identity, and race that impact their interactions with learners and affect their learners' sense of inclusion.

Connections to Next Generation Science Standards (NGSS)

BEETLES student activities are designed to incorporate the three-dimensional learning that is called for in the NGSS. Three-dimensional learning weaves together Science and Engineering Practices (what scientists do), Crosscutting Concepts (thinking tools scientists use), and Disciplinary Core Ideas (what scientists know). Learners should be exploring and investigating rich phenomena and figuring out how the natural world works. The abilities involved in using Science and Engineering Practices and Crosscutting Concepts—looking at nature and figuring things out, using certain lenses to guide thinking, and understanding ecosystems more deeply—are mindsets and tools learners can take with them and apply anywhere to deepen their understanding of nature, and they're interesting and fun to do!

In *Case of the Disappearing Log*, learners engage in the Science and Engineering Practice of *Constructing Explanations* and have the opportunity to relate what they learn to the Crosscutting Concept of *Cause and Effect*. Learners also build a foundational understanding of Disciplinary Core Ideas related to *Interdependent Relationships in Ecosystems* (LS2.A) and *Cycles of Matter and Energy Transfer in Ecosystems* (LS2.B).

Featured Science and Engineering Practice

Engaging learners in *Constructing Explanations*. According to the National Research Council'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 learners should develop their understanding of science concepts by making their own explanations about natural phenomena.

- In *Case of the Disappearing Log*, learners make tentative explanations when they discuss what might have caused the log to change or "disappear."
- For example, a learner 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.
- Learners can deepen their engagement with the practice by consciously using tentative language ("I think that..."), basing their explanations on evidence and considering alternate explanations based on that evidence.
- Using the information in the key offers an additional opportunity for learners to make explanations based on evidence.
- The part of the activity in which learners 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 learners to include their evidence and reasoning when they give an explanation and to entertain alternate explanations for the same phenomenon.

Featured Crosscutting Concept

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*, learners apply ideas of cause and effect as they examine the log and make possible explanations for what might be causing the features they observe (e.g., holes, frass).
- The instructor offers some framing around the scientific application of cause and effect by sharing that analyzing cause-and-effect relationships is an approach scientists also use when trying to decipher the mysteries of the natural world.

TEACHING NOTES

About the Next Generation Science Standards (NGSS). The development of the NGSS 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 toward engaging learners 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 learners to 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 (DCI's). The DCI's 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 https://www.nextgenscience.org/ **and** https://www.nsta.org/nstas-official-positions/next-generation-science-standards

TEACHING NOTES

- Offering this framing and scaffolding can support learners to recognize the idea of cause and effect as a useful thinking tool and important way of looking at the natural world.
- Invite learners to consider how the idea of cause and effect also applies in other scenarios, such as making predictions about what might happen in the future or explaining past events.
- To continue to support learners in applying cause and effect as a thinking tool, 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 learners need multiple learning experiences to build their understanding of Disciplinary Core Ideas. *Case of the Disappearing Log* provides learners with an opportunity to develop understanding of some life science core ideas related to *Interdependent Relationships in Ecosystems* (LS2.A) and *Cycles of Matter and Energy Transfer in Ecosystems (*LS2.B).

- When learners observe features of a decomposing log and then use a key to identify the specific decomposers associated with certain features, they have an opportunity to 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. Learners also have an opportunity to build understanding of how organisms depend on their interactions with living and nonliving parts of their ecosystems. (LS2.A)
- As learners discuss where the matter in the log has gone, they can build some understanding of how matter cycles between the air, soil, and among plants and microbes as those organisms live and die. (LS2.B)
- As the instructor, you can invite learners to relate their observations and explanations to these DCI's by sharing ideas and content at the end of the activity about where the matter in the log goes. You can also invite learners to notice that they have been exploring the process of decomposition.
- Don't miss the opportunity to make these connections at the end of this activity and continue to offer learners opportunities to continue to develop their understanding of these ideas related to interdependent relationships in ecosystems in additional activities.

You can informally assess learners' understanding of these concepts during different stages of the activity in individual interactions with learners and by listening carefully during the group discussions. This information can help you decide which ideas to focus on in future lessons so follow-up activities or discussions can be used to further learner understanding.

Performance Expectations to Work Toward

No single activity can adequately prepare learners for an NGSS Performance Expectation. Performance Expectations are designed as examples of things that learners should be able to do to demonstrate their understanding

Translating the codes for the NGSS Performance Expectations. Each standard in the NGSS is organized as a collection of Performance Expectations (PE's) for a particular science topic. Each PE has a specific code, which is 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 grade, 2 = second grade, 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 is addressed by the PE, and the last digit identifies the number of the PE itself. So, 3-LS4-4 means the Performance Expectation is part of a third-grade standard (3) for life science (LS), addressing the fourth core idea (4), Biological Evolution: Unity and Diversity, within the life science standards, which deals with Biodiversity and Humans. It's also the fourth Performance Expectation (4) that makes up the complete LS4 standard at this grade level.

of content and big ideas in science after engaging in multiple learning experiences and instruction over a long period of time. They are *not* the curriculum to be taught to learners. Following are a few Performance Expectations this activity can help learners work toward:

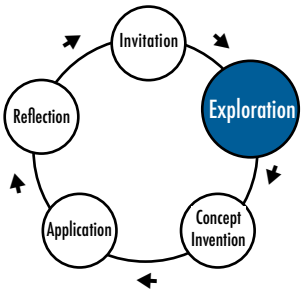
- **5-LS2-1.** Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
- **MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Activity Connections

The activities *I Notice, I Wonder, It Reminds Me Of* and *NSI: Nature Scene Investigators* can offer learners the opportunity to build skills of observation, curiosity, and scientific discourse that support them to engage in *Case of the Disappearing Log*. *Hand Lens Introduction* taught before this activity helps learners become comfortable with this important tool. For a similar but more focused activity in which learners learn about the impacts of bark beetles, try *Bark Beetle Exploration*. For a follow-up activity that allows learners to develop detective and explanation skills in a broader setting, try *Tracking*.

To continue to develop learner understanding of Disciplinary Core Ideas related to interdependent relationships in ecosystems and matter cycling, use the activities *Decomposition Mission*; *Food, Build, Do, Waste*; *Matter and Energy Diagram*; *What Lives Here?*; *Card Hike*; and *You Are What You Eat*. The *Ecosystems (and Matter) Theme Field Experience* offers ideas on creating a sequence of all these activities to build learners' understanding of concepts related to ecosystems, matter, and energy over the course of 2–6 hours.

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



Learning cycle. As part of a sequence of activities focused on decomposition and interdependent relationships in ecosystems, this activity functions as an Exploration.

CAUSE AND EVIDENCE CARDS—for older learners

CAUSE

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.

CAUSE

I might be a deer, bear, squirrel, porcupine, mouse, rabbit, moose, or beaver. Sometimes I strip bark off trees to eat it, eat insects or sap under the bark, or make nests with the bark. If I am a deer or moose, I might rub my head and antlers on the tree to mark my territory.

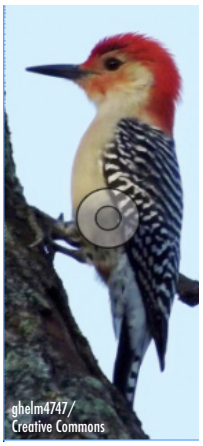
CAUSE

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, and white cellulose in wood. I get into living or dead trees where bark has been damaged.

CAUSE

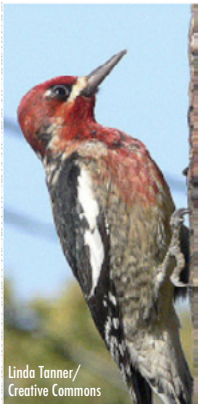
I am a type of brown rot fungus. I break down and consume the white cellulose in wood. I leave behind the brown parts of cell walls (lignin) in brown cube-like sections. I get into living or dead trees where bark has been damaged.

CAUSE



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.

CAUSE



I am a kind of woodpecker called a sapsucker. I make holes in living trees. The holes 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.

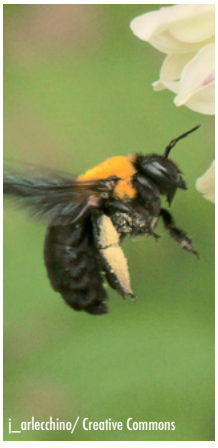
CAUSE

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.

CAUSE

I am a human being. I cut down trees to use lumber to build things, and I 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.

CAUSE



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.

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Find the latest activities and information at http://beetlesproject.org.

CAUSE AND EVIDENCE CARDS—for older learners (continued)

CAUSE

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.

CAUSE

K Schneider/ Creative Commons

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

CAUSE

Kevin Beals

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

CAUSE

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.

CAUSE AND EVIDENCE CARDS—for younger learners

CAUSE

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

CAUSE

I might be a deer, bear, squirrel, porcupine, mouse, rabbit, moose, or beaver. Sometimes I strip bark off trees to eat it, eat insects or sap under the bark, or make nests with the bark. If I am a deer or moose, I might rub my head and antlers on the tree to mark my territory.

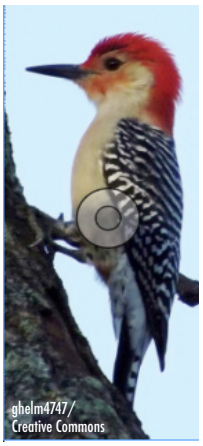
CAUSE

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

CAUSE

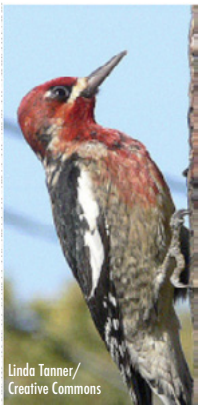
I am a type of brown rot fungus. I consume part of wood and leave behind the brown parts of wood in cube-like sections.

CAUSE



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.

CAUSE



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

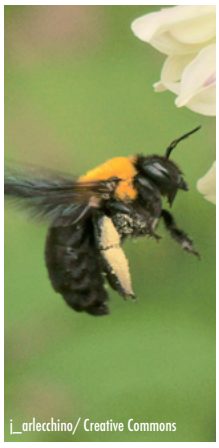
CAUSE

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

CAUSE

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

CAUSE



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

CAUSE AND EVIDENCE CARDS—for younger learners (continued)

CAUSE

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.

CAUSE

K Schneider/ Creative Commons

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

CAUSE

Kevin Beals

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

CAUSE

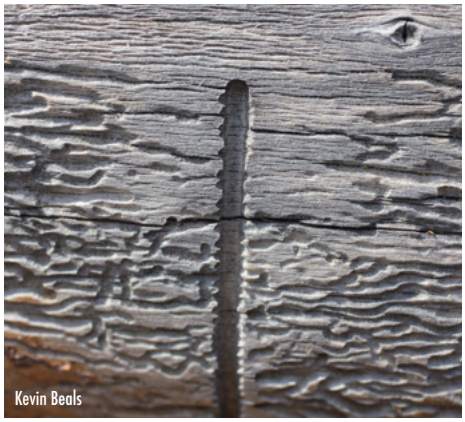
Cody Hough/ Wikimedia Commons

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.

CAUSE AND 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

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

CAUSE AND EVIDENCE CARDS (continued)

EVIDENCE

sapsucker holes
(a type of woodpecker)

EVIDENCE

woodpecker hole
(from a woodpecker other than a sapsucker)

EVIDENCE

termite tunnels

EVIDENCE

stump

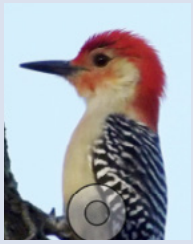
DECOMPOSING LOG KEY

HOLES

holes bigger than a dime

Kevin Beals

woodpecker (other than sapsucker)



ghelm4747/Creative Commons

holes smaller than a dime

round, barely smaller than a dime

Tony Alter/ Creative Commons

carpenter bee

j_arlecchino/ Creative Commons

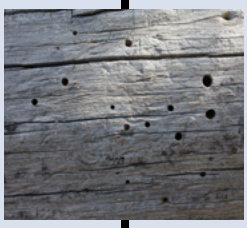
close together in rows

Whitney H, Creative Commons

sapsucker (type of woodpecker)

Linda Tanner/Creative Commons

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



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boring beetle

Cody Hough, Wikimedia Commons

TUNNELS

clean, straight tunnels with smooth edges

Bjorn Fritsche/ Creative Commons

carpenter ant

Kevin Beals

smooth and shallow designs just under the bark

Kevin Beals

bark beetle

Siga/ Wikimedia Commons

rough and ragged tunnels with dirt and wood bits inside

Kevin Beals

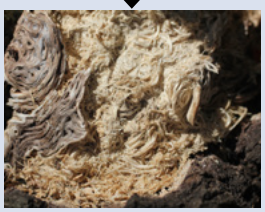
termite

K Schneider/ Creative Commons

CRUMBLING WOOD

yellow or white, spongy or stringy wood

white rot fungus



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cubes of brown wood

brown rot fungus

Kevin Beals

DECOMPOSING LOG KEY

BURNT WOOD

black bark or hollow tree

Mingo Hagen/Creative Commons

forest fire →

H Dragon/Creative Commons

STRIPPED OR 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 and Rabbit: Thermos/ Wikimedia Commons

CHEW MARKS

tooth marks low on tree

Gordon E. Robertson/ Creative Commons

beaver →

Marie Hale/Creative Commons

AX OR SAW MARKS

smooth slice of wood

Kevin Beals

human logging →

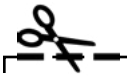
H Dragon/ Creative Commons

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

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

FIELD CARD

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



Case of the Disappearing Log

Introducing the Activity

1. Share:
   - *Move into the circle IF . . .*
   - *You've ever lost something and tried to figure out where it went.*
   - *You have a favorite detective or scientist from a book, movie, story, or real life.*
   - *You've heard the word* evidence. *[Ask them to define it.]*
   - *You know what a cause is. [Ask them to define it.]*
   - *You've ever tried to figure out a mystery. [Ask a few to share.]*
2. Share: You'll be acting as detectives today, trying to explain a nature mystery based on evidence you find.
3. Move to the decomposing log and unveil the mystery—Case of the Disappearing Log.

Initial Explorations

1. Share: You'll explore and observe the log together in pairs, looking for evidence that the log is disappearing.
2. While learners explore, model and encourage making observations and asking questions.
3. If learners are losing interest, invite them to observe the log from a different perspective.

Initial Sharing and Discussion

1. Gather the group. Learners share observations and evidence in pairs.
2. A few learners share their observations with the whole group. Lead a short discussion about what they noticed.
3. As learners share, invite others to use signals to show agreement and participate in the discussion.
4. Offer cause and effect as a thinking tool when discussing evidence of the disappearing log.
5. Learners *Turn & Share* about possible explanations for what might have caused evidence they observed.
6. A few learners share their explanations with the group.

Optional: Cause and Evidence Cards

1. Give each learner either 1 Cause Card or 1 Evidence Card.
2. Those with Evidence Cards stay put, while those with Cause Cards move around looking for a match.
3. Once holders of matching Cause Cards and Evidence Cards find one another, pairs read their cards together.
4. Circulate and offer support.
5. Matched pairs mingle and introduce themselves to other pairs.

Exploring with a Key

1. Share: You'll learn more about what might be causing the log to disappear.
2. Share: You'll use a key to identify causes and connect them with evidence.
3. Show how to use a key by talking through one example.
4. Invite learners to use the key while working in teams to figure out which causes left behind different kinds of evidence on the log and to identify as many causes as they can that could be connected to evidence they find.
5. Encourage learners to look for evidence of where the tree stood and to make possible explanations for how the tree fell and the order of causes and events that impacted the log.
6. Older learners only: Distribute full sheets of Cause Cards to use information on the sheets in explaining the possible order of events.
7. Circulate, offer support, be a co-investigator, ask questions.

Discussing Explanations

1. Gather the group, and each team shares their explanations with another team.
2. A few groups of learners share with the whole group their explanations and sequence of what happened to the log, using language of uncertainty.
3. Encourage respectful disagreement and ask for other possible explanations.

FIELD CARD

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4. Focus the discussion on the relationship between causes and the environment and ecosystem around the log.
   - *What organisms might have benefited from the tree/log you investigated?*
   - *What do organisms that are breaking down the log get from the log?*
5. Offer: Scientists also engage in discussions with peers to come up with best explanations.
6. Invite learners to notice how thinking about cause-and-effect relationships can be used as a tool to understand what has happened and to develop possible explanations.
7. Return the focus to Case of the Disappearing Log and ask where the matter in the log has gone.
   - *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.*
   - *Let's think back to the log we observed at the beginning of this activity. Where is the missing wood now? What happened to the rest of the matter—in other words, the "stuff" that the log is made of? Where could it have gone?*

   Multiple learners share their ideas, agree/disagree with one another, and share evidence.
8. Share: Learners have been basing their explanations on things they can observe with their senses (such as termite poop, holes, and tunnels), but there are things that can be hard to detect with human senses.
9. Share:
   - *Scientists know matter can't be destroyed or disappear into nothing.*
   - *Matter that is no longer part of the log has changed into other types of matter, some of which we can observe, and some we can't.*
10. Review one or more ideas learners shared about where matter from the log has gone, making connections to how each form of matter eventually becomes gases.
    - *In discussions, we've shared that some matter from the log is now insect poop or part of an insect's body, and we've found strong evidence for that.*
    - *What we can't see is that any insect that ate wood not only pooped out some of the matter but also breathed out matter, or "stuff" that used to be part of the log, as gases into the air, such as carbon dioxide and water. There is carbon dioxide and water in the air that used to be the log!*
    - *Another thing we can't see is that what is insect poop now will eventually be consumed by living things too tiny for us to see, like fungi and bacteria. Those fungi and bacteria will breathe out matter as air that was insect poop.*
11. Invite learners to breathe in and consider where the air has come from.
    - *Breathe in air. Some of that air may have been part of this log or other logs.*
    - *The same is true of soil, crumbled wood, or* [share examples brought up earlier]*, etc.*
    - *Matter from the log is now part of those things, and eventually all of it will become part of air.*
12. Share:
    - *Animals breathe in gases from the air, and so do trees and other producers. Plants and algae breathe in carbon dioxide and take in water, changing them into plant matter—such as trees, which eventually die and become logs.*
13. Share:
    - *Matter in the log didn't actually disappear—it just changed form.*
14. Share:
    - *Invisible gases are essential for all ecosystems and could be absorbed by other plants and become part of other logs and living things*

Wrapping Up and Reflecting

1. Invite learners to keep looking at trees, logs, and other wood throughout the field experience and to keep looking for more mysteries and evidence of decomposition.

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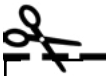

2. Throughout the field experience, invite learners to continue to think about how matter (some invisible) is cycling around in the ecosystem.
3. Keep the keys and cards handy so learners can refer to them when they become curious about other decomposing wood.
4. Encourage learners to continue using cause-and-effect thinking to explore and figure out nature mysteries.
5. Whole-group discussion or *Thought Swap* (choose some questions below):
   - *What are questions you have about decomposing logs and 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 a family member or friend?*
   - *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 organisms be in the wood in your house?*

ABOUT BEETLES™

BEETLES™ (Better Environmental Education Teaching, Learning, and Expertise Sharing) provides environmental education programs nationally with research-based approaches and tools to continually improve their programs.

www.beetlesproject.org

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