How Can Wildfires Lead to Mudslides?

Middle School • Discipline: Earth Science • Time: One 45-minute class period

Lesson Level Performance Expectation:
Develop and use a model to explain the cause and effect relationship between two natural hazards: wildfires and mudslides.

What Students Will Figure Out
● After a wildfire the soil changes to contain a high amount of waxy substances
● Simple models can be used to test competing ideas and to help us understand why the risk of a mudslide increases after a wildfire

Lesson Snapshot:
Middle school students, as scientists, investigate natural hazards to answer this driving question: How can wildfires lead to mudslides? Our Beautiful Planet: After the Flames introduces students to two phenomena: the 2017 Montecito wildfire and the 2018 Montecito mudslide. Students develop an initial model to explain what happens during a rainstorm on a mountain slope before and after a wildfire. Next, students plan and perform an investigation to test their ideas. Using evidence from the investigation and additional information from the film, students revise their model to explain how the Montecito wildfire led to a mudslide. Students use their model and information from the film to propose methods of warning communities about future mudslides.
How Can Wildfires Lead to Mudslides?

Middle School • Discipline: Earth Science

Phenomenon:
Montecito, California Wildfire (12/4/17-1/12/2018) and Montecito, California Mudslide (1/9/2018)

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
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</thead>
<tbody>
<tr>
<td>Constructing Explanations and Designing Solutions</td>
<td>ESS3.B: Natural Hazards</td>
<td>Cause and Effect</td>
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<tr>
<td>• Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3)</td>
<td>• Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.</td>
<td>• Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td>
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<td>Developing and Using Models</td>
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<td>• Develop and use a model to describe phenomena.</td>
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This lesson could be one in a series of lessons building toward: MS ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

Materials

<table>
<thead>
<tr>
<th>Student Materials</th>
<th>Teacher Materials</th>
<th>Optional Teacher Resources</th>
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<tbody>
<tr>
<td>Per Student</td>
<td>Note that the exact amount of materials needed will vary depending on the investigation planned by students. The amounts listed below assume students do two tests with two different types of soil: regular potting soil and potting soil with a thin layer of wax within.</td>
<td></td>
</tr>
<tr>
<td>• none</td>
<td>• Our Beautiful Planet: After the Flames film</td>
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<td>Per Small Group (2 to 4 students)</td>
<td>• measuring tape</td>
<td></td>
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<tr>
<td>• n/a</td>
<td>• 3 small (3 oz.) paper cups</td>
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<td></td>
<td>• 30 cm. (1 ft.) section of plastic downspout</td>
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<td></td>
<td>• potting soil—enough to fill at least 2 small (3 oz.) paper cups</td>
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<td></td>
<td>• paraffin wax—enough to create a thin layer inside the potting soil (approximately 1 cm. thick)</td>
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<td>• 1 large, shallow, clear plastic waterproof tub (20 cm. x 36 cm. x 76 cm.)</td>
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<td></td>
<td>• duct tape</td>
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<td></td>
<td>• scissors</td>
<td></td>
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<tr>
<td></td>
<td>• support for downspout (for example, books or chair)</td>
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Lesson Preparation

Montecito Hills Model

1. See the Teach Engineering Mini-Landslide activity for a diagram of what the finished model should look like.
2. Use duct tape to secure the downspout (chute) to the bottom of the tub at a shallow angle. The soil material should not slide down the chute on its own.
3. If needed, use a stack of books or a chair to support the top end of the chute.
4. Create the potting soil and wax mixture by pouring potting soil into one of the small cups, leaving about 2 cm. of room at the top. Create a layer of paraffin wax that is approximately 1 cm. thick, then put 1 cm. of soil on top of it.

Experience the Phenomenon

What Students are Doing:
In this section, students consider the following phenomenon: Montecito, CA had a wildfire and a mudslide within several months of each other. Students share what they notice and wonder about the phenomenon. Students construct an initial model to explain what caused the mudslide.

Teacher Guidance

1. Introduce the phenomenon.
Tell students you want to share with them two natural hazard phenomena that had a large impact on a town in California a few years ago: a wildfire and a mudslide. Give students a few minutes to share any experiences or prior knowledge they have about wildfires or mudslides. Once a few students have shared, ask everyone to create a two-column notice-and-wonder chart in their science notebooks or on a blank sheet of paper to use to record their observations and questions as they watch a film clip in a moment.

Sample Notice-and-Wonder Chart

<table>
<thead>
<tr>
<th>What I notice</th>
<th>What I wonder</th>
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2. Play the film Our Beautiful Planet: After the Flames from the start to 3:38. Skip to 6:13 and play to 7:40.
Give students a moment after you stop the film to finish their noticings and wonderings and then ask the class to share what they noticed. Record all student ideas publicly on a piece of chart paper or a board.

Some potential noticings:
- Fires were huge/largest fire CA had seen, 7 homes burned
- The fire burned for weeks
- Winds made the fire spread
- Lots of smoke
- After the fire the trees were dead
- The hillside went from being covered with plant and trees to having just a few dead stumps sticking up
- There was nothing but dead trees and dirt no other plants, bushes or grass
- It rained really hard a few weeks later
- A river of mud came rushing down
- The mud also picked up stumps of dead trees and giant rocks/boulders
- The mud was going right through people’s houses
- 130 houses were destroyed, 23 people lost their lives
Once all of the noticings have been shared and posted, ask students to share some of the wonderings they recorded as they watched the film (or any new wonderings they may have after sharing noticings with the class).

Some questions students may have:
- How do wildfires make other disasters happen?
- Were there ever any mudslides before the fire?
- Did fire make the mudslide happen?
- How did the fire make the mudslide happen?
- How could mud cause so much damage?
- Why didn’t the mud slide down the hill before the fire?
- How could mud pick up tree stumps and boulders?
- Why didn’t they have a way to stop the mud?
- Is there any way to prevent this from happening?

3. Focus on the possible connection between the mudslide and wildfires.
Point out that many of the students’ questions are wondering about a possible connection between the mudslide and the wildfires. Tell students that now they will consider how the mudslide might be connected to the wildfires.

Suggested Prompts:
- Ask students to share what they know about fire on a smaller scale (paper or plant material burning, campfires, etc.). Facilitate the discussion so that students surface the idea that ash and other substances are left behind when plants burn.
- Delve a bit deeper here. You might say, “Do you think the wildfire could change the soil in Montecito in some way?” If the question about whether or not the soil has changed is not on the list of student questions yet, you should be able to add it after this discussion.
- Another avenue to get more ideas and questions on the board is to ask students if they have heard about other wildfires or mudslides. This prompt could bring out more questions about whether or not these natural hazards are always connected. It may also give students a reason to look at other environmental conditions and get some questions related to those topics on the board (or ideas into their initial models).

4. Facilitate the development and discussion of models to explain what caused the mudslides.
Give students 5 minutes to create an individual model to explain what caused the mudslides. You might choose to provide students with a template (see example below) to support them in developing their model.

As students create their individual models, circulate around the room to look for those who may be struggling. If students are stuck, consider helping them make connections to the observations they recorded and the models they are creating. For example, comments such as “It looks like there are some things you noticed in the film, but I’m not seeing them on your model. How might you include some of those ideas?” with more or less specificity can help a student get started while still using their own ideas.

After the five minutes have passed, ask students to move into groups of 3 or 4 to share their models. Give each student 30 seconds to explain their model to the group. When all students have shared, ask them to record the similarities and differences among the models.

Give the small groups a chance to share the similarities and differences they noticed in their models with the whole class, and check in with other groups to see if they also had some of the same elements. Use chart paper or a board to publicly record a list of similarities and differences in students’ initial models.
Highlight areas of disagreement among students’ models. You might say to students, “We don’t seem to agree how the changes to the mountain slope after the wildfire could cause a mudslide to occur. How might we investigate?”

**Ideas students may come up with could include:**
- We could burn plants and test the soil to see if it is different.
- We could find a hill with trees and without trees and pour water down it to see what happens.
- We could make a model of a hillside to test these ideas.

**Additional Guidance: Class Discussions**
For more information about different types of class discussions and class discussion facilitation, consult the OpenSciEd resource 3 Discussion Types.

**Investigate the Phenomenon**

**What Students are Doing:**
In this section, students plan and perform an investigation to test their ideas. Using evidence from the investigation and additional information from the film, students revise their model to explain how the Montecito wildfire led to a mudslide.

**Teacher Guidance**

5. **Facilitate a discussion to determine the investigation students will perform.**
Agree with students that they could make a model hillside to test their ideas. Introduce the materials you have to create the model.

Show students the chute and tub. Ask students to consider what the chute and tub will represent in their investigation. Answers will vary, but students should converge on the idea that the chute represents the mountain slope and the tub represents a town or city below the hills.

Tell students that you have regular potting soil and a soil mixture that mimics the type of soil that scientists have found after intense wildfires (soil with a wax layer right below the surface). Allow students to handle samples of the two different soils and record their observations. Students should note that the post-wildfire soil mixture feels waxy. Inform students that the bits of wax represent the residue found in soils after a wildfire.

Say, for example, “We are investigating how changes to the mountain slope after the wildfire could cause a mudslide to occur. What seems like the most simple test to get us started? It looks like we have some questions about how the soil is different after the fire and some other questions about how the change in the soil affects the risk of a mudslide. Let’s test that first. How should we do that?”

Facilitate a discussion to get students to develop a protocol for testing the soils. The following discussion prompts can help students develop the protocol and decide what data is important to collect from these tests. Record the protocol publicly on a piece of chart paper or a board.
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**Suggested Prompts:**

- How should we set up the tests?
  - How should we set up a test to represent a rainstorm on a mountain slope before a wildfire? (*Put regular potting soil in the chute.*)
  - How should we set up a test to represent a rainstorm on a mountain slope after a wildfire? (*Clear the remains of the first test, and put the soil-and-wax mixture that mimics the type of soil found after intense wildfires in the chute.*)
  - How much soil should we put in the chute for each test? (*One 3-oz. cup of soil is recommended. It is important for students to note that they should use the same amount of each type of soil.*)
  - How much wax should we put in the soil-and-wax combination? (*Students can use the 1 cm.–thick mixture created by the teacher or can choose a different amount based on how much wax is available. If time and materials allow, students could test different amounts of wax.*)
  - How much water should we use to represent the rain? (*One 3-oz. cup of water is recommended. It is important for students to note that they need to use the same amount of water for testing both types of soil.*)
- What should we measure? (*Options—the time it takes for the soil to start to move down the chute, the distance the soil travels, or the amount of soil that moved*)
- How will we know if the wildfire affects the risk of a mudslide? (*We can look for differences in the data for the before-and after-wildfire tests: how fast the soil goes down the chute, how far the soil travels, or how much soil travels.*)
- What variables do we need to keep the same between tests? (*We should keep the chute at the same angle. We should make sure to clear the chute and tub between tests.*)
- How should we keep track of this data? (*We could record it in a table in our science notebooks.*)

**6. Perform the Investigation with students.**

Give students time to create a table in their notebook to record the data. You may choose to co-construct this table on a board with the class to help students who may need more support organizing this. Start testing the soils in an area where all students are able to see the demonstration.

- Place a small amount of water on the chute to ensure that each trial starts with the chute slightly wet.
- Perform a test that represents rainfall on a mountain slope before a wildfire, following the protocol that students developed.
- Clean the chute and move any potting soil in the tub to the side.
- Perform a test that represents rainfall on a mountain slope after a wildfire, following the protocol that students developed.

You may have student volunteers come to the demo area to make measurements and call out the numbers for everyone to record in their own tables.

After the tests have been conducted and students have recorded the data, ask students to make connections to the Montecito mudslide.

**S= Discuss the results with a partner and how this model might be similar or different from what happened in the Montecito mudslide.**

**T= If students are having difficulty making connections, consider the following prompts.**

1. In our tests, was the mudslide worse before or after the wildfire? What evidence supports this connection? (*Depending on the investigation, students might cite differences in the amount of soil that traveled, the time it took for the soil to travel, and the distance the soil traveled.*)

2. During the Montecito mudslide, a lot of soil, mud, and water traveled quickly down the hills into homes and businesses. Based on the data you collected and what you know about wildfires and soil, what do you think the soil in Montecito felt like right before the mudslide? (*For example, dry, wet, waxy?*)
How Can Wildfires Lead to Mudslides?

Ask students, “What new questions does this raise?” Students should wonder how a wildfire makes the soil feel waxy. Explain that you have a film that discusses some work that scientists are doing to study soils after wildfires. Play the film Our Beautiful Planet: After the Flames from start to finish.

Provide students time to revise their initial model based on evidence from the investigation and information presented in the film. Then ask students to share with a partner what they added and/or changed and what evidence they used to support these revisions to their model.

Facilitate a whole-class Consensus Discussion. Help students consider alternate explanations and develop a common explanation. You might use some or all of these questions to help facilitate the discussion:

- What are some things we can say about the phenomenon (wildfire that led to a mudslide)?
- What evidence supports your explanation?
- How are these explanations similar? How are they different?
- Is the evidence presented sufficient to conclude that the wildfire caused the mudslide? If not, what additional evidence is needed?

Provide time for students to make changes to their models based on the ideas shared in the whole-class discussion.

Additional Guidance: Mudslide Model
The Mudslide Model activity was developed from a TeachEngineering lesson titled Mini-Landslide. This lesson includes more rounds of testing and could be used if time and interest allow.

Explain or Model the Phenomenon

What Students are Doing:
In this section, students use their model and information from the film to propose methods of warning communities about future mudslides.

Teacher Guidance

7. Tell students that they will now use what they learned to think about future mudslides with a partner.

- How could Dr. AghaKouchak and his team use science ideas, cause-and-effect relationships, and data to warn people about future mudslides?
- Brainstorm other ways that you could possibly predict and warn people about mudslides.
- Do you think this is the only piece of the puzzle? What other investigations could we perform to find out if some of our other ideas also contribute to the likelihood of a mudslide?
- Should everyone who lives under a hill or mountain that has experienced a wildfire be warned about mudslides? Or are additional variables involved that could be used to identify the communities with the highest risk? (For example, the slope of the hill; repeated freezing and thawing of the ground)

8. Facilitate an Initial Ideas Discussion.

Suggested Prompts:

- Why would it be important to warn people about future mudslides?
- How could we use the information we figured out in this investigation to help warn people about future mudslides?
- What additional information would be useful to know who is most at risk for future mudslides?