

What Holds a Hillside Up? Slope, Water and Earth Material

Learning target: I can use evidence from a reading to explain how slope steepness, saturation and earth material decide whether a hillside fails, and how communities use that knowledge to forecast landslides and reduce harm.

Reading with evidence

About 40 min

Individual

MS-ESS3-2 · practice

MS-ESS2-2 · supports

reading

writing

Name _____

Date _____

Period _____

Directions

Read the passage once all the way through. Then read it again with a pencil: underline each place where it explains how steepness, water or earth material affects a slope, and put a star next to each California example. When you answer, name the paragraph you used (P1 to P6), and quote or paraphrase the words that support your answer.

You will need: This worksheet, Pencil, Highlighter (optional), Scrap paper for the reading guide

The Tug-of-War on Every Slope

[1] Every hillside is in a quiet tug-of-war. Gravity pulls each grain of soil and each block of rock toward lower ground. Holding material in place are friction between grains, the grip of plant roots, and the natural cement and clay that bind particles together. While the holding side is stronger, the slope stays put. When gravity wins, soil and rock move downhill, and geologists call that mass wasting. To judge which side is winning, they look at three things: how steep the slope is, how much water is in the ground, and what the slope is made of.

[2] **Steepness.** On flat ground, gravity pulls straight down into the earth, so nothing slides. Tilt the ground and part of that pull now points along the surface, downhill. The steeper the slope, the larger that downhill part becomes, and the smaller the part that presses grains together, which is what creates friction. Pour dry sand into a pile and its sides settle at roughly 30 to 35 degrees; extra grains simply slide off. Natural slopes steeper than that stay up only because roots, cement or interlocking rock add strength. Anything that steepens a slope moves it closer to failure: a river cutting into the bottom of a hill, waves undercutting a sea cliff, or a bulldozer carving a road.

[3] **Water.** A small amount of water can actually help. Damp sand lets you build a tall sandcastle wall because thin films of water pull neighboring grains together. Once rain soaks in until every space between grains is full, though, the soil is saturated, and the help turns into harm. The water adds weight. Even more important, water trapped in those pore spaces pushes outward on the grains and partly lifts them apart, so the friction between them drops. A hillside that held firm all summer can give way after a week of storms. That is why most California landslides happen in the wet months, and why many start a day or more after a storm begins.

[4] **Earth material.** Loose sand, weak shale and clay-rich soil fail more easily than solid granite. Clay causes extra trouble: it absorbs water and turns slick, and a clay layer underground can stop water from draining deeper, so water builds up in the soil above it. Rock shattered by faults or cracked by weathering has many weak surfaces to slide along. Wildfire changes the material too. It burns away the plants whose roots hold the soil, and it can leave the surface water-repellent, so rain rushes off instead of soaking in and carries ash, soil and rock with it.

[5] **California cases.** The beach town of La Conchita, in Ventura County, sits below a steep bluff of weak, broken sedimentary rock. In 1995 part of the bluff slid and destroyed several homes. In January 2005, after about two weeks of very heavy rain, part of that old slide moved again, and 10 people died. In January 2018, a short burst of extremely intense rain fell on mountains above Montecito that the Thomas Fire had burned weeks before, and debris flows raced down the canyons, killing 23 people. In May 2017, after an extremely wet winter, a huge slide at Mud Creek on the Big Sur coast buried about a quarter mile of Highway 1, which stayed closed for 14 months.

[6] **Forecasting and reducing harm.** No one can name the exact day a hillside will fail, but scientists can map where failures are most likely by combining slope steepness, rock and soil types, the locations of old landslides and expected earthquake shaking. After a wildfire, they estimate how likely debris flows are in each burned canyon and how intense the rain must be to set them off, so forecasters can warn people when a storm that strong is coming. Engineers attack each cause: drains pull water out of a slope, retaining walls and anchored nets hold material back, new plants protect the surface, and debris basins catch flows before they reach homes. The strongest plans combine several defenses with warnings, so people can leave before a slope lets go.

Part A: What the passage says

1. Using P2, explain why making a slope steeper brings it closer to failing. Your answer must mention both parts of gravity's pull that the paragraph describes.

2. Which statement about water best matches P3?

- ☐ A. Any amount of water makes soil weaker, so even damp soil is weaker than dry soil.
- ☐ B. A little water can hold grains together, but saturated soil is heavier and has less friction between its grains.
- ☐ C. Water matters only when it freezes and cracks the rock.
- ☐ D. Water causes slides only by adding weight to the slope.

3. P4 says a clay layer underground can make a slope more dangerous. Give the two reasons the paragraph offers.

4. According to P4, name two ways a wildfire makes debris flows more likely on the burned slopes.

Part B: Use the evidence

5. For each California case in P5, write the evidence the passage gives about steepness, water and earth material. Write 'not stated' if the passage gives no evidence for that factor.

Steepness	Water	Earth material
La Conchita, 2005		
Montecito, 2018		
Mud Creek, 2017		

6. P3 says many slides start a day or more after a storm begins. Use the idea of saturation to explain why a slope might not fail during the first hours of rain.

7. La Conchita's 2005 slide happened where part of an old slide moved again. Use P6 to explain why scientists include the locations of old landslides when they map where future failures are likely.

8. Choose two engineering defenses from P6. For each one, name which factor from P2 to P4 (steepness, water or earth material) it works against and explain how.

9. A county can pay for only one landslide program this year: (1) a map of where slides are most likely, or (2) a rainfall warning system for canyons below last summer's burn scar. Using evidence from at least two paragraphs, argue which program you would choose for a town at the foot of those burned canyons, and explain why either program gives a forecast rather than an exact prediction.

A three-column reading guide

Before answering, fold a scrap of paper into three columns labeled Steepness, Water and Material. As you reread P2 to P6, write a few words in the right column each time the passage explains how that factor helps or hurts a slope, along with the paragraph number. Most answers in Part B can be built straight from your columns.

Why not just pave it?

A neighbor suggests covering a whole hillside with concrete so rain cannot soak in. Using the passage's ideas about water and earth material, write a paragraph about what this would fix and what new problems it could cause, such as where the runoff would go and what happens if water still seeps in from above or behind the concrete. Propose a better combination of defenses and explain your reasoning.