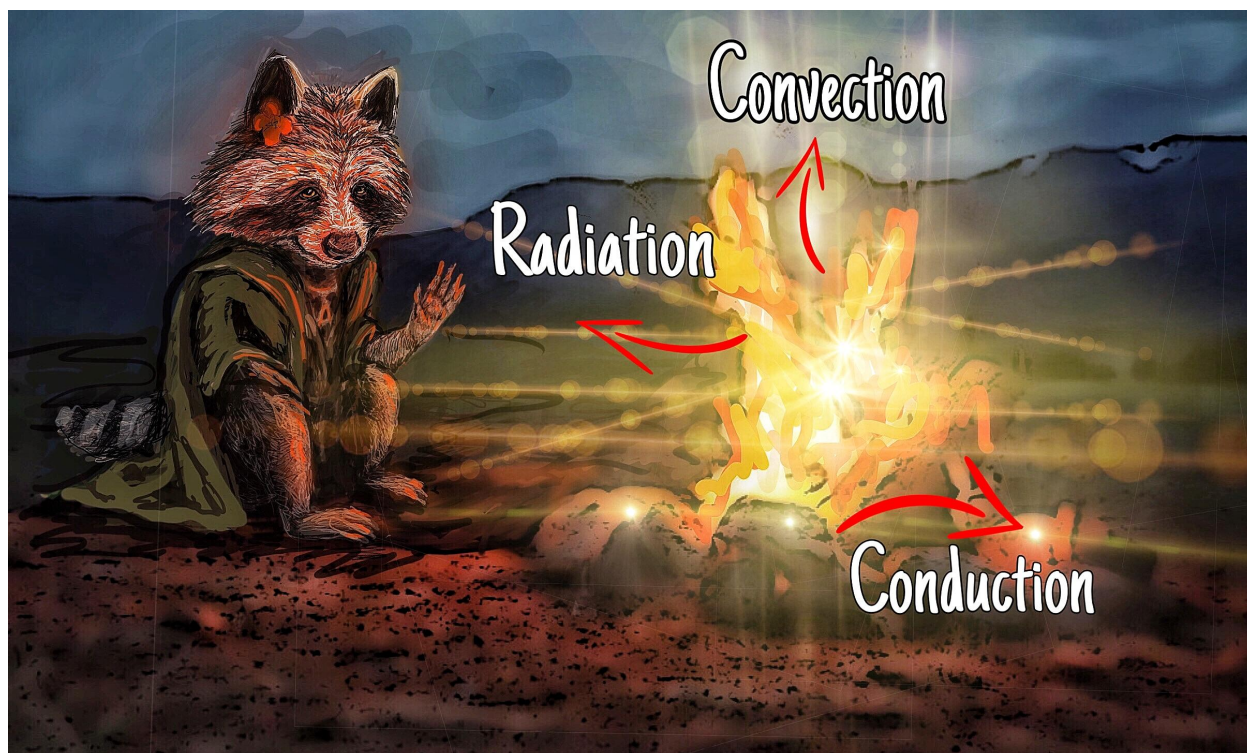


4- TERRAIN, HEAT TRANSFER & FIRE RATE OF SPREAD



INTRODUCTION

Students learn how the steepness of terrain (slope) and heat transfer influences fire behavior. They will observe, measure and journal the relative steepness of the terrain by using angles estimated with hands, fingers, body position and movements.

LESSON OVERVIEW & ESTIMATED TIME (60 MINUTES)

- Safety Discussion and Grounding Exercise on Slope (5 mins)
- Fire Behavior Triangle and Slope Angle Review (10 minutes)
- Hand Slope Measurement Exercise (5 minutes)
- Landscapetto Slope Measurement Exercise (10 minutes)
- Heat Transfer, Slope and Fire Behavior Review (10 minutes)
- Heat Transfer Comparison Table (5 minutes)
- Heat Transfer Slope Discussion (10 minutes)
- Fire Rate of Spread (3-5 minutes)

MATERIALS & RESOURCES

- Journal or notebook
- Graphite pencils, erasers, crayons or colored pencils

LOCATION

The exercise is ideally conducted in the real-world but not all locations are suitable for viewing terrain. It is recommended to use the same landscape-scale viewpoint as lesson #1 or use the [AlertWildfire live web cameras](#) or Google Earth. The view does not have to be looking exactly at

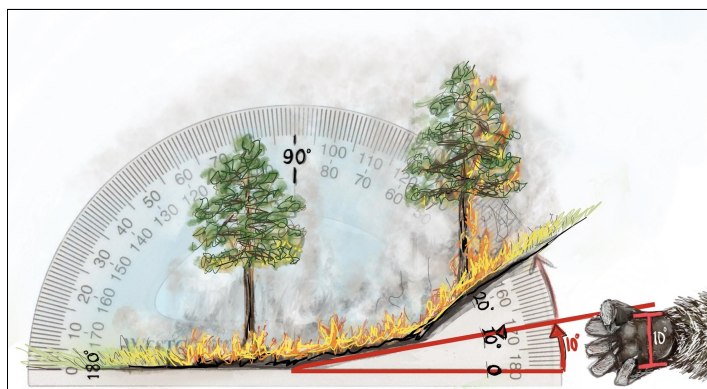
where the students are currently but a scene that captures the general terrain of the local area - steepness.

BACKGROUND & NATURAL PHENOMENA INVESTIGATED

We are referring to terrain as the physical features of the landscape. In fire management the term topography is used to describe the physical features of land, but terrain is a more relatable term for the purposes of this guide. The terrain features are typically formed by natural processes but can also be altered and created by human activities such as mining, road creation and flood management features. In this lesson we are not identifying and naming terrain features but observing the steepness of a hill or mountain slope and relating that to fire behavior. Some terrain features like boulders and sand dunes can hinder fire movement while others like steep hills and canyons can increase fire spread.

- Let's stand up again for a different grounding exercise. Feel your feet connect with the ground. Sense your body as a straight post/board in the ground.
- Look out at the landscape you've been journaling about and find a hill or mountain you like. Think about that hill or mountain as another creature and look at the shape of its body. How curved is the back? To communicate with them, you'll need to use your hands, arms and body to address it by its name. Its name is a hand, arms and or body gesture or movement that resembles the slope or steepness of its back.
- Reach out to your hill or mountain creature and address it with your gesture/movement. Say hello, and tell it something you see about it (e.g. you are a tall, steep mountain).
- Now let's get your journal and materials ready to write and sketch information, ideas, and questions about your observations and feelings.

FIRE BEHAVIOR TRIANGLE & TERRAIN OVERVIEW (10 minutes)



You learned that the fire behavior triangle influences how fire moves across the landscape and includes topography (landforms), fuels (vegetation) and weather in the first lesson. Terrain influences fire in a number of ways but one of the basic principles is that the steeper the incline or slope, the faster fire will burn over the landscape.

Fire scientists have determined that a slope of 20 percent or more can have major influences on fire behavior. We'll learn more about this in a minute.

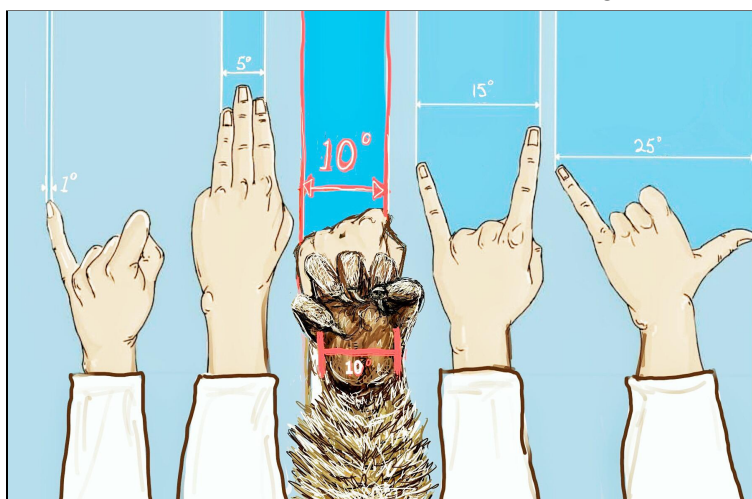
- To estimate how steep a slope is, we can use mathematics, but let's save that for another class. We will consider tools like a protractor or measurements using your hands

to estimate the angle and slope.

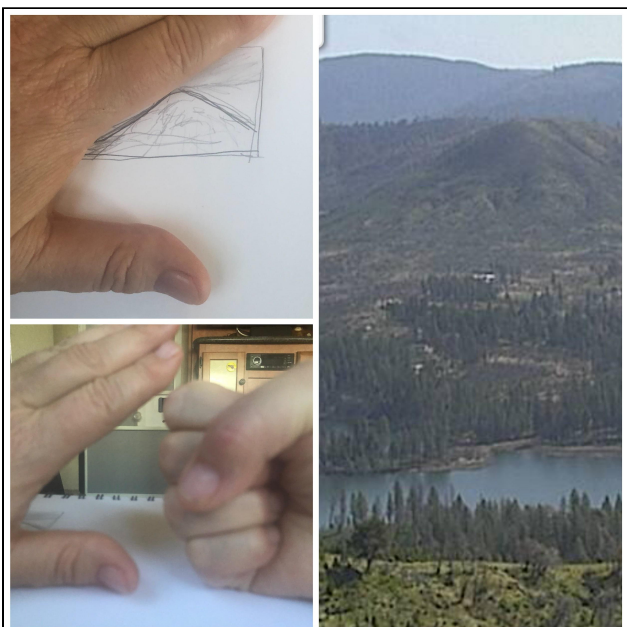
- NOTE: A 10° angle equals a 17.6% slope. For simplicity in the field exercises, let's just say that a 10° angle equals a 20% slope.
- Look at the protractor and landscape slope image above and how the angle degrees listed on the inside/bottom line on the protractor measure up to the landscape slope.
- In the image above, the REDI Jedi Raccoon is overlaying her fist to indicate the hand method for estimating the 10° angle (20% slope) that we want to remember and use in our landscape and fire observations. We can call it the “fit your fist” method in the gap between the slope angle and bottom (zero angle).

HAND SLOPE MEASURE EXERCISE (5 minutes):

- Teacher demonstrates the hand gesture measures for the different angles and has the students follow along. Emphasize the fist as the measure important for this exercise and for the slopes that can indicate more significant fire behavior.



LANDSCAPETTO SLOPE EXERCISE (10 minutes)

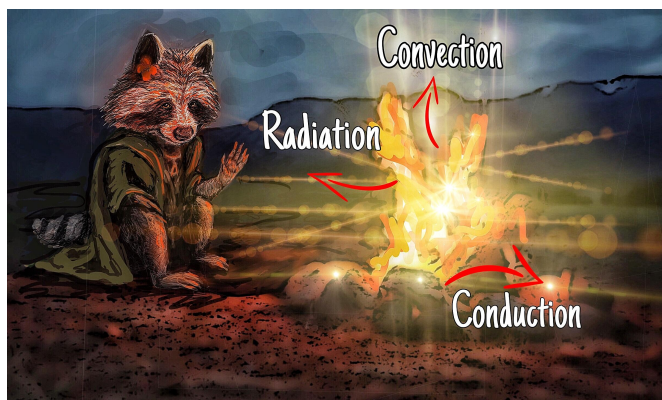


- Look out at your landscape view and pick a hill to estimate if it is less than or more than a 10° angle and 20% slope. Tell the students they will have five minutes to complete this exercise.

- Teacher demonstrates how to create another small landscapetto box of any shape (square or rectangle) on the journal page. Explain how to draw the shape/outline of the hill you are looking at, inside the box, with the bottom of the box as the zero line of the angle.

- Teacher demonstrates as students follow. Hold your left hand over the angle on the sketch you created with the thumb balanced at zero degrees and the fingers resting on the slope. Keep that angle on your left hand and bring your right hand fist to the same distance out and see how it fits in the gap of the angle. Is the gap bigger or smaller than the fist?
- Students write on their landscapetto hill and slope sketch or diagram whether the hill is less than or more than a 10° angle = 20% slope. This is not the most accurate measure but can help give a sense of slope steepness and potential increased fire behavior.
- Ask if there are questions about the assignment or if students need help sketching the box and hill, shaping their hands to the view and slope and or writing down the measurements on their landscapetto.
- Let students know when they have about a minute left to finish what they are working on.
- Ask students about what they came up with. Do they have other questions about slopes and fire? If so, have them write the questions.
- down on their journal near the this landscapetto sketch.

HEAT TRANSFER, SLOPE AND FIRE BEHAVIOR REVIEW (10 minutes)



- Now that we have an idea of how to estimate the angle and steepness of a slope, let's dig in a little deeper to why a sleeper slope increases how fast a fire will spread.
- A fire spreads by transferring heat energy in three ways: Radiation, Convection, and Conduction.

Radiation refers to the emission of energy in rays or waves. Heat moves through space as energy waves. It is the type of heat one feels when sitting in front of a campfire. It travels in straight lines at the speed of light. This is the reason that when facing the fire, only the front is warmed. The backside is not warmed until the person turns around.

Convection is the transfer of heat by the physical movement of hot masses of air and gases. As air is heated, it expands and becomes lighter than the surrounding air and it rises straight up, unless pushed to by the wind. (This is why the air near the ceiling of a heated room is warmer than that near the floor.). A convection column is formed above the fire which can be seen by the smoke that is carried aloft in it.

Conduction is the transfer of heat within the material itself, like the soil and rocks near the campfire. Wood and vegetation are poor heat conductors, so not an important factor in the spread of forest fires.

HEAT TRANSFER COMPARISON TABLE (5 minutes)

- Think about how to help students frame questions. If they appear stressed by the topic, do another grounding exercise.
- Ask students if they have any questions and tell them they have ten minutes to complete. It may take less time.
- Have students create another comparison table with three-columns and label them as Radiation, Convection and Conduction. Have them use words, pictures and or numbers to compare the differences.

HEAT TRANSFER AND SLOPE DISCUSSION (10 minutes)

- Tell students to look back at the protractor and landscape slope illustration and use those to help discuss the following questions and write in their journals?
- Students discuss as a group with the teacher or in small groups and discuss the questions below.
- Students can add other questions of their own or if they are struggling to write questions, consider asking them to sketch a large question-mark to express that they don't know what their questions are. Putting question-marks all around a journal page to express what you don't know or where you want to know more is a part of the nature journaling process.
- Tell students that fire scientists have determined that when the hillsides reach a 20 percent slope, flames will double in height and be four times as fast, without wind considerations, which can expand those numbers. Can you see how all three types of heat transfer overlap and combine on a higher slope or angle? That increases the amount of heat and how fire will behave and grow.

Patterns

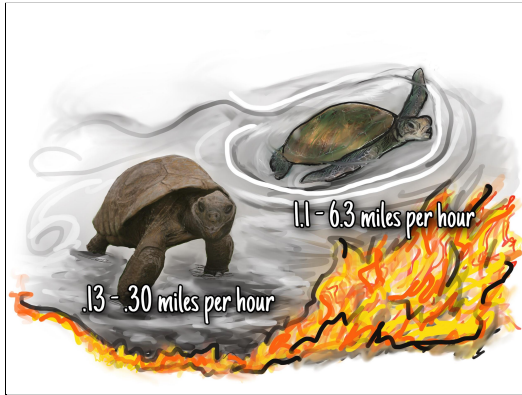
- What are some patterns you noticed in how the flames move on flat ground and steeper slopes?
- What are some slope patterns you noticed in the landscape scene you were viewing?

Cause and Effect

- What were some differences between some of the flames on flat ground and on steeper slopes? What are some possible causes for the differences?

FIRE RATE OF SPREAD (2 minutes)

A term used in fire management to estimate and measure the speed a fire travels is called the fire rate-of-spread (ROS). There are mathematical formulas and software programs that can estimate ROS based on the mix of topography (slope), fuels (vegetation) and weather variables. But for our nature journaling purposes, we'll consider a visualization for the average range of the ROS. On average, fires move at a ROS similar to that of a tortoise ambling across the desert and up to the speed of a sea turtle flying through the ocean.



A. Ask students if they can imagine a prescribed or cultural burn where fire is moving around the landscape at the speed of a tortoise to create healthy patches of wildlife habitat.

B. Imagine an average wildfire that is being pushed by the wind and fire is moving across the landscape like a sea turtle swiftly swimming on the ocean currents.