6. Effect of Wind: How Wildland Fires Spread

Lesson Overview: In this activity, students participate in a human model that shows how wind affects fire spread.

Lesson Goal: Increase students' understanding of wildland fire spread as affected by weather.

Objectives:

- Students can participate in a physical model of a forest (or other standing fuels).
- Students can use the Fire Triangle to explain how wind affects fire spread.

Subjects: Science, Writing, Speaking and Listening, Health and Safety
Duration: One half-hour session
Group size: Whole class
Setting: Indoors or outdoors
Vocabulary: *backing fire, downwind, head fire, spot fire*

Standards:		1st	2nd	3rd	4th	5th
CCSS	Writing	2, 7, 8	2, 7, 8	2, 7, 10	2, 7, 9, 10	2, 7, 9, 10
	Speaking/Listening	1, 2, 4, 6	1, 2, 4, 6	1, 2, 4, 6	1, 2, 4, 6	1, 2, 4, 6
	Language	1, 2, 4, 6	1, 2, 4, 6	1, 2, 3, 4, 6	1, 2, 3, 4, 6	1, 2, 3, 4, 6
NGSS	Engineering Designs		ETS1.B			ETS1.B
	Earth's Systems			ESS2.D		
	Earth and Human Activity				ESS3.B, ETS1.B	
EEEGL	Strand 1	A, B, C, E, F, G				A, B, C, E, F, G
	Strand 2	A				A

Teacher Background: Weather has a profound influence on wildland fire. Air temperature, the amount of moisture in the air (measured as relative humidity), short- and long-term precipitation, and wind are all important. Wind is the most difficult of these to predict and the one most likely to change erratically during a fire. In this activity, students create a physical model that shows how wind affects fire spread.

Students learned in **Activity E03** that most of the heat from a fire tends to go upward. They called this the "heat plume." Hot gases rise because they are less dense than the surrounding air, and air at the ground is usually denser than that above it due to gravity. A gust of wind is like a bubble of dense air. It bends the heat plume so it is no longer vertical but instead leans over - toward whatever fuels lie downwind. Wind also bends flames so they are more likely to touch the downwind fuels. For these reasons, fires tend to spread more rapidly with the wind than against it or in still air.

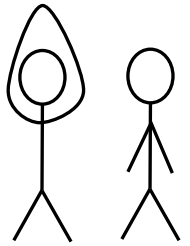
When the wind is blowing uphill, it adds to the effect of slope and accelerates fire spread. When the wind is blowing crosswise or downhill, its effects are harder to predict. A fire burning uphill or with the wind is called a "head fire"; a fire burning against these influences is a "backing fire." Of course, even if slope and wind favor a fast-spreading head fire, the fuels may be too far apart to sustain combustion, as the students observed with the matchstick forests in **Activity E04**, when they observed boards with 49 matches vs. boards with only 5 to 12 matches on them.

Materials and preparation:

None

Procedure:

1. Show students that each of them can "model" the heat plume. If you pretend that your head is a match tip – or the crown of a tree or the top of another standing fuel, then you can show the shape of a heat plume by clasping your hands together high above your head. Your shoulders, arms, and hands represent the outside of the heat plume. A little heat is going down and to the sides, while a lot of it is going up. Ask the students to imitate you – so each of them becomes a model of a heat plume.



2. Explain: When they stand with their hands at their sides, each of them will be a model of a living tree (or other standing fuel), and their heads will represent the tree crowns. When they stand with their hands arched above their heads, each of them will be a model of a tree with its crown on fire!

3. Have students line up side by side in a straight line with their arms at their sides – modeling living trees - about half an arm's length apart. Have 1-2 "trees" at the far end of the line stand 2-3 arms' lengths away from their nearest neighbor and also separate from each other. Select 2-3 students from the near end of the line to help you in the next step.

4. Explain: The students in the line are modeling a forest stand. Most of the trees are close together, although the ones at the far end are a bit further apart. The trees are not on fire, so the students should keep their hands at their sides.

5. Have the class make the sounds for a crash of lightning and a loud rumble of thunder. Tell the "tree" at the near end of the line that he or she has been struck by lightning and fire has run up through ladder fuels into the tree crown. Ask: How does that look? The student should now clasp hands above his/her head, modeling the heat plume of a tree with its crown on fire. Point out that the heat plume goes straight up. It does not reach the next student in line, so that student's hands remain by his/her side, and the fire is not spreading.

6. Now have your helper students act out a gust of wind running up to the "burning tree" at the near end of the line. Include sound effects!

7. Have the "burning tree" show that the wind bends its heat plume over so it reaches the next "tree" – which is ignited. Keep the "wind" students going strong, so the next and the next trees are ignited too. Ask: What do we call this kind of fire, which is running from treetop to treetop? It is a crown fire (a term that they learned in **Activity E04**). Explain: A fire spreading with the wind or up a hill is also called a head fire, while a fire spreading into the wind or downhill called a backing fire.

8. Continue the wind and fire spread until the "fire" ignites the second-last tree. Ask: Can that tree bend its heat plume enough to ignite the last one? If so, the entire forest has burned in a crown fire; if not, this part of the forest is too open for crown fire to spread, and the crown fire must stop.

9. Ask: Are there other ways for the fire to spread to that unburned tree? The fire could spread along the surface rather than through the crowns. It could also "spot" ahead of the main fire front if the wind carries embers from the burning tree crowns forward, downwind of the fire. It is very common for strong winds to produce spot fires a kilometer or more ahead of the fire front.

10. Ask: Use the Fire Triangle to explain how the wind in this forest model changed the fire behavior. The wind pushed the heat from a burning tree toward its neighbor tree. If the flames touched the neighbor tree, it was ignited. A gust of wind is like a big bubble of dense air, so the wind also increased the amount of oxygen reaching the fuels.

11. Ask: Do you think the effects of wind on fire are similar to the effects of slope, which we looked at with the matchstick forests in **Activity E04**? Wind and slope both put the flames closer to fuels on one side (the uphill side or the downwind side), so the fuels dry out and heat up faster and ignite more easily than fuels on the other side. If there is no fuel on the uphill/downwind side, of course, the fire cannot spread in that direction.

Assessment: Ask students to write answers to these 2 questions:

1. Why do you blow on a campfire to make it burn better? Use 2 parts of the Fire Triangle to explain. You blow on a campfire to push the <u>heat</u> and flames into the unburned <u>fuels</u>.

2. Why do you blow on a candle to put the flame out? Use 2 parts of the Fire Triangle to explain. You blow on a candle to push the heat away from the fuel (which is the melted wax in the candle wick).

   If the student uses oxygen in his/her explanation, evaluation is more complicated; he/she should receive credit for any part of this explanation:

   - Because your breath is denser than the air around you, it might be increasing the oxygen available to the fire.
   - However, your exhaled breath contains only about 2/3 as much oxygen as the air around you, so you might not be increasing the oxygen available after all.
   - Furthermore, your breath is probably moister than the surrounding air, so you would be increasing the humidity around the fire, and – since the moisture absorbs some of the heat - that would make the fuels harder to burn.

Evaluation:	**Full Credit**	**Partial Credit**	**Less than Partial Credit**
	Uses 2 components of Fire Triangle correctly.	Uses 1 component of Fire Triangle correctly.	Uses 0 components of Fire Triangle correctly.