Activity 3-4. The Fire Triangle in Wildlands

Grade levels:
X Middle
X High

What's the Point?

The Fire Triangle tries to capture the concepts underlying wildland fire behavior—a powerful, highly variable force of nature. When you're looking at a match or a candle, it looks simple. In wildlands, it usually isn't. Instead, it is complicated, intriguing, and dramatic.

In this activity, students construct and demonstrate some principles of fire behavior for the class. They use matches to model trees and a matrix of matches to model a forest. They compare fire behavior on different slopes and with different arrangements of trees. They also view a 3-minute videotape of wildland fires burning in three layers of the forest—surface, crown, and ground fuels. They interpret the fires in the videotape in terms of what they have learned about fire behavior and the Fire Triangle.

Teacher's Map:

Objectives: Given a physical model of a forest stand, students can describe effects of slope and tree density of fire spread. After viewing a videotape, students can identify three kinds of fire behavior—surface, crown, and ground fire.

Subjects: Science, Math., Writing, Speaking and Listening, Workplace Competencies

Duration: 50 minutes

Links to Standards[16]:

National Science Teachers' Association—Grades 5-8:

A1) Identify questions that can be answered scientifically
A2) Design and conduct a scientific investigation
A3) Develop explanations and predictions using evidence
A4) Think critically to establish relationships between evidence and explanations
A5) Communicate procedures and explanations
B2) Describe physical and chamical changes
B3) Understand that energy is transferred in many way
B4) Identify ways in which energy moves in and out of a system
F1) Identify potential for accidents, make choices that minimize risk of injury
F3) Recognize extent, sources and challenges of natural and human-induced hazards

National Science Teachers' Association—Grades 9-12:

A2) Design and conduct experiment, use models to explain results
B3) Understand basic chemical reactions
F1) Identify hazards, make choices that minimize risk of injury
F3) Recognize extent, sources and challenges of natural and human-induced hazards

North American Association for Environmental Education—Grades 5-8:

1B) Design investigations to answer questions
1D) Judge weaknesses and strengths of information being used
1G) Synthesize observations into coherent explanations

[16] See Appendix 4 for links to Montana educational standards, grades 5-8 and 9-12.

cont'd.

2.1C) Understand energy transfer 2.4A) Understand that human-caused changes affect environment ***North American Association for Environmental Education—Grades 9-12:*** 1B) Design investigations to answer particular questions 1D) Apply logic to assess completeness and reliability of information 1G) Use evidence and logic to develop hypotheses 2.2C) Understand the living environment as comprised of interrelated, dynamic systems

Vocabulary: chemist, crown fire, density, ecologist, firestorm, forester, ground fire, model, physicist, range manager, slope, spot fire, surface fire, wildlife biologist

Materials

In this trunk...	***...where?***[17]	***You must supply***
Kinds of Fire videotape (3 min.)	Teacher/C	VCR and monitor
Tree Portrait poster	Main/B	Wooden matches (lots)
*Fuels, Tree Parts…*kit	Teacher/C	Metal trash can without liner
Matchstick forest kits (4)	*Hardware Box*, Main/A	overhead projector
Fire extinguisher	Main/B	Copy of Student Page 5 for each team
Burning trays	Main/A	
Class Page 2 (transparency in *FireWorks Visual Aids/Handouts*)	Teacher/C	
spray bottles with water (2)	*Hardware Box*, Main/A	

Procedure

1. Set up the class with four student teams. Explain that this activity is similar to research done by chemists and physicists. Results from research like this are used by foresters, firefighters, range managers, wildlife biologists, and ecologists.
2. Explain that each team will set up different experiments, but the whole class will observe every fire. So, in effect, the student teams are setting up demonstrations for the whole class.
3. Review safety procedures in the laboratory; use the *Fire Safety* poster or other lab rules.
4. Give each student team a matchstick forest model (drilled square of masonite, 2 bolts, 1 nut-and-washer set, 1 nail) and 50-100 matches. Ask students to insert a match in every hole of the matchstick forest model, tips pointing up.
5. Set these "matchstick forests" in burning trays on a heat-resistant surface. If you don't have laboratory facilities, one really good surface to use is a trash-can lid filled with sand. Let the first "forest" be level; to the second and third, attach a short bolt so the slope is about 20 degrees. To the fourth, attach the long bolt so slope is about 40 degrees. Have a spray bottle and fire extinguisher nearby.
6. Explain to students that the individual matches represent trees that have flammable crowns, like the conifers in local forests. In this demonstration, students will observe how slope and

[17] Entry to left of slash is for Packing Arrangement 1 (large tub plus Teacher Box); Main=Main Trunk, Teacher=Teacher Box. Entry to right of slash is for Packing Arrangement 2 (three cartons, labeled by letter).

tree density affect fire spread through tree crowns. Before lighting the matches, ask students for their guess (hypothesis) about how the fires will differ.

Figure 6—Middle school students ignite their “matchstick forest” while younger students “patrol” for unsafe practices.

7. Light the match tips along one edge of the flat "forest" and observe fire behavior. Then light the match tips along the top edge of a medium-slope forest and observe. Then light the bottom row of matches on the other medium-slope forest and observe. Finally, light the bottom row of matches on the steep forest and observe (fig. 6). Ask for descriptions of what the students observe and interpretations in terms of the Fire Triangle. (Heat travels upward, so the matches and trees uphill from a fire receive more heat than those below and are easier to ignite.) Optional: Ask students to answer Questions 1-3 on Student Page 5.
8. Ask students to remove whatever remains of the matches from each board. They can use the nail in the kit to poke the burned matches out, if necessary.
9. Explain that the arrangement of "trees" in the matchstick forests studied so far resembles the arrangement in lodgepole pine/subalpine fir forests. Show Class Page 2 on the overhead projector. This table describes the number and arrangement of trees in ponderosa pine/Douglas-fir forests and whitebark pine/subalpine fir forests. Ask students to set up matchstick forests resembling these two forest types—using the long bolts to make "steep" forests. Ask how they expect fire behavior to differ.
10. Light these matchstick forests, one at a time, and discuss or record observations on Student Page 5, lines 4 and 5.
11. Ask each student team to construct a matchstick forest to solve a problem. Here are two possibilities: (1) Your matchstick forest is on a steep slope. You can remove 12 trees from it. Find the best arrangement of 12 fewer trees (a total of 37 remaining) to reduce the risk of fire spread. (2) You are in the timber business, and most of your land is on moderate slopes. You need to reduce the risk of fire spread on your land, but you want to raise as many trees as possible. What’s the best density and arrangement for your trees?
12. Light these matchstick forests, one at a time, and discuss how well each team solved the problem.
13. Ask the students to compare the model forests used in this experiment to real forests. What are the similarities? What are the differences? How would they expect wildland fires to differ from matchstick fires?

14. Explain: Real wildland fires are much more complicated than model fires. Show the 3-minute videotape *Kinds of Fire*. Ask students which kind of fire (surface, crown, or ground) was modeled in their matchstick forests? (crown fire)
15. Explain**: Spot fires** (mentioned in the videotape) can be started by small fires, including slash burns, as well as large, severe fires; the spot fires started by large fires, however, may start a long distance from the main fire. Any time there are several fires in an area, caused by numerous spot fires or lightning strikes or any other source, they can influence one another and even merge into a large, severe "**firestorm**."

Evaluation:

1. Use a sketch to show how slope affects fire spread.
2. If you double the number of trees in a forest, what happens to the fire danger?

Closure: On the *Tree Portrait* (poster from the trunk), attach the laminated cards identifying the locations where fires can burn (ground, surface, and crown).

Extensions

1. Read and report to the class on the 1997 *Discover* article about lightning, in the *FireWorks Library.*
2. View the videotape *International Crown Fire Modeling Experiments* (in the *Teacher Box*) to see what researchers are doing to learn more about very severe fires and safety measures.
3. Learn about wildland fires on a national scale by consulting the U.S. "National Fire Occurrence Maps" on the Internet at

   www.fs.fed.us/fire/fuelman
4. What's going on right now in the firefighting business? To find out, visit the National Interagency Fire Center's Internet site:

   www.nifc.gov

Class Page 2

Arranging Trees in the Forest 100 Years Ago

Three kinds of forest, three arrangements of trees.

What kind of forest?	How many trees in a matchstick model?	How are the trees arranged?
Lodgepole pine/subalpine fir	49	Trees are dense and quite evenly spaced.
Ponderosa pine/Douglas-fir	5	Trees occur singly, occasionally in pairs.
Whitebark pine/subalpine fir	13	Trees occur in clusters of 2 to 5.

The matchstick model represents 1/40 hectare (1/15 acre),
a square 16 m (about 50 ft) on a side.
Is this bigger than your classroom?

Student Page 5

Names: _____

The Fire Triangle in Wildlands

In this demonstration, you watch fires on three slopes--flat, medium, and steep. Answer questions 1-3 using the demonstration fires as examples.		
1	How does the steepness of a hillside affect a fire's spread?	
2	How well do fires burn downhill?	
3	How does slope affect fire spread? Use the Fire Triangle to explain.	
Now you will burn two more "matchstick forests" to explore how the arrangement of trees affects fire spread. Answer the questions below.		
	Description of matchstick forest	How well did this arrangement resist crown fire?
4	Ponderosa pine/Douglas-fir forest 100 years ago (5 large trees in area where lodgepole pine might have 50 trees)	
5	Whitebark pine/subalpine fir forest (13 trees, growing in clusters of 2-5 trees, in area where lodgepole pine might have 50 trees)	
6	Use the Fire Triangle to explain.	