1. Color each sketch to show a typical fire.

   A. Ponderosa pine:

   B. Lodgepole pine:

   C. Whitebark pine:

2. Write:
   At least one sentence about how fires B and C are the same.
   
   At least one sentence about how fires B and C are different.
   
   At least two words that describe their feelings in response to the photo presentation.
Lesson Overview: In this demonstration, students observe the heat from a burning candle and a single match so they can describe the shape and size of a heat plume and explain how the energy from a fire is transferred. Since this is the first activity in FireWorks to use actual fire, we suggest it as a demonstration so the class can go through and observe safety procedures together.

Lesson Goals: Increase students’ understanding of heat dispersal from fires. Prepare students to safely conduct experiments with fire.

Objectives:
- Students can list three ways in which energy is transferred from a burning object.
- Students can describe the shape and size of a heat plume from a burning match.
- Students can list some safe practices for doing laboratory experiments with fire.

Subjects: Science, Mathematics, Writing, Speaking and Listening, Health and Safety

Duration: one half hour session

Group size: Do as demonstration to whole class.

Setting: Laboratory or outdoors area sheltered from wind

New FireWorks vocabulary: conduction, convection, heat plume, radiation

Teacher Background: Most of the heat energy from a burning object usually disperses upward because the process of burning releases hot gases. The air at ground level is denser than that above because of gravity, so most of the hot, expanding gases of combustion tend to go upwards. The process in which warm gases and liquids generally move up, and cool ones move down is called convection. The heat plume from a fire does not always go straight up, however. A gust of wind, which can be thought of as a bubble of dense air, can push the hot gases sideways or even downward.
There are two other ways to transfer energy from a fire: conduction (the movement of energy from one atom or molecule to another in a solid) and radiation (the movement of energy through space by particles or waves). The demonstration in this activity explores all three means of heat transfer from a single burning match.

**Materials and preparation:**
Choose your location. This demonstration can produce flames 10-15 centimeters long. Can you do this safely in your classroom and without setting off a smoke alarm? Can you take your students to a lab where it will be safer? Do not try this demonstration outdoors because even the slightest wind will blow out a single match.

- Display the *FireWorks Safety* poster (*M02_FireWorks_Safety_poster.pptx*).
- Get a box of wooden kitchen matches.
- Fire extinguisher, fully charged
- Get a package of pre-wrapped hard candy. You’ll need about twice as many pieces as you have students.
- Set up laboratory bench or other area to be used for demonstration with the following equipment (available in the trunk):
  - spray bottle, filled with water
  - ruler
  - metal tray (i.e., cookie sheet)
  - ashtray
  - votive candle
  - safety goggles
  - oven mitt
  - support stand
  - cross-piece for support stand. Has an alligator clip at each end.
  - clamp
- Set up the support stand with the clamp and cross-piece as illustrated above. Clip a match to one end with the ignitable tip pointing down.
- Draw the graph on the right on the board or project *M02_GraphForDescribingHeatPlume.pdf*.
Procedure:

PART ONE: Students demonstrate the 3 methods of heat transfer

1. Explain: In this activity, the class will work together to make observations about heat transfer from fires. As background, you need to know three terms: convection, conduction, and radiation. We’ll set up a human demonstration to learn what they mean.

2. Have students stand side by side in a long line, shoulder to shoulder. Explain and do:
   
a. Conduction: If they were atoms within a solid object, like a metal, they would move heat energy by passing it from one atom to another, each atom absorbing some and passing some on. (Pass the bag of candy to the first student, who takes a piece and passes it to the next, who does the same... all the way to the end of the line.)

b. Radiation: Get the candy bag back (if there’s any left!). Now pretend you are a source of light and heat, like the sun, radiating energy. You transfer that energy by sending out particles or waves through space. The energy travels until it contacts an atom or molecule, which it then heats up. (Throw a few pieces of candy directly to a few students.) Radiation explains how you can get a sunburn from energy that travels through space. Amazingly, the molecules of your skin are the first ones that sunlight touches in its 93-million-mile journey!

c. Convection is the expansion of a bubble of hot gases into the cooler gases surrounding it. Gravity holds Earth’s atmosphere to the ground, so the air becomes “thinner” (less dense) as you go up in altitude. Since “up” has less resistance to expanding gases than “sideways” or “down,” hot air and the hot gases produced by combustion generally rise. Ask the class to imagine that their shoulder-to-shoulder line is vertical rather than horizontal. Pick 1-2 students to walk with you, arm-in-arm, from one end – the imaginary bottom of the heat plume – toward the other end, the imaginary top. Give a piece of candy to each student you pass – this means that your bubble of hot gases is losing heat as you go up, warming the surrounding air. If you run out of candy, stop. This means your bubble is the same temperature (i.e., has the same amount of energy per volume) as the air around you.

3. Have students take their seats for the next steps.
PART TWO: Students measure the shape of a heat plume

1. Explain: The class will work with the teacher to SAFELY measure the shape of a heat plume and learn how a fire can transfer heat through conduction, radiation, and convection.

2. Go through the FireWorks Safety poster (M02_FireWorks_Safety_poster.pptx) with the class, checking your demonstration set-up to make sure all guidelines are met.

3. Demonstrate how to SAFELY light a match: Pull the match away from you, not toward you; hold it level or tilted slightly downward, not pointing directly downward; drop it into the ashtray or metal tray if it feels too hot. Always dispose of burned matches in the ashtray or on the metal tray.

4. Get a volunteer from the class to be the Observer. Make sure he or she is dressed safely, following the poster guidelines.

5. Get another volunteer to be the Measurer and another to be the data Recorder.

6. Explain to the Observer: Your job is to find out how tall and wide the heat plume is from a burning match. You’ll start by holding one hand about 40 centimeters to one side of the match. When the match is completely on fire, you’ll bring your hand in closer until you can sense a change in temperature. The goal is to sense even a LITTLE warmth – NOT to see how close you can get without getting burned! We’ll use as many matches as needed to get observations from two sides of the flame, above it, and below it. When you make the “below” observation, don’t put your hand directly under the burning match, in case the tip breaks off and falls. Instead, hold your hand just a little to one side.

7. Explain to the Measurer: After each match is out, you’ll measure the distance from its tip to the observer’s hand (in centimeters).

8. Explain to the Recorder: You’ll mark the correct axis of the graph to show each measurement.

9. Light the first match. As soon as it is completely on fire, obtain a “side” measurement and record it. After the match goes out, USE THE OVEN MITT to remove it from the clip, put a fresh one in, and get the opposite “side” measurement... a “below” measurement... then an “above” measurement. If you forget the oven mitt, you will quickly – and painfully – learn

FireWorks Safety

When you do experiments with fire...
1. Wear cotton clothing. No synthetic pants, soccer shorts, etc.  
2. Wear closed-toed shoes. No sandals or flip flops.  
3. Tie back loose sleeves.  
4. Tie back loose hair.  
5. Make sure a fire extinguisher is close. Make sure it is charged. Know how to use it.  
6. Make sure spray bottles are close and filled with water.  
7. Wear safety goggles when burning.  
8. Never lean over a fire.  
9. Extinguish burned materials with water before putting them in the trash. Fire is not out if there is any smoke or heat coming from the fuels.  
10. If a fire starts on you, stop, drop, and roll.

Use fire ONLY if a responsible adult is working with you.
about conduction. Use as many matches as you need to get the 4 observations. Use the same Observer for all 4 measurements. If you want to see variation from different observers, have another student or two repeat the observations, and then calculate an average for each dimension on the graph.

10. Have the Recorder connect the marks on the four axes, making a roughly oval shape.

11. Refer back to the three ways in which heat is transferred in a fire – conduction, convection, and radiation. Discuss/explain: The heat plume’s strong tendency to move upward demonstrates convection. Radiation sends energy in every direction; the heat you feel to the sides and beneath the flame is due to radiation. Conduction of heat is occurring from the fire into the metal clip, which is why you are using the oven mitt.

12. **Clean up:** Make sure all matches are out before you dispose of them – that is, until there is no smoke and no heat being released. Use a metal trash can without a plastic liner. If in doubt, dump the materials in a bucket of water before putting in the trash.

**Assessment:** Ask students to write/sketch answers to the following:

1. Where did the heat go? Use heat-transfer terms to describe the movement of heat upward, sideways, downward, and into the metal pieces?

2. Sketch a burning candle and show the shape of the heat plume. Label the diagram with words and arrows to show where convection and radiation are occurring.

3. Make a list of safety precautions that you should take when you get ready for school on days when fire experiments are scheduled. You can refer to the FireWorks Safety poster. Have students take the list home and post it in a place that they can refer to as they prepare for school.
<table>
<thead>
<tr>
<th>Evaluation:</th>
<th>Correct</th>
<th>Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Where did the heat go? Use vocabulary.</td>
<td>Most of the heat went upward through <strong>convection</strong>, the tendency of hot gases and liquids to rise.&lt;br&gt; A little heat went in every direction through <strong>radiation</strong>, the process in which energy travels through space as particles or waves until it hits a molecule, which it heats up.&lt;br&gt; Some heat went into the metal clip by <strong>conduction</strong> (the transfer of heat from particle to particle within a solid).</td>
<td>Student’s descriptions did not reflect the correct use of the vocabulary term or a general understanding of the concept.</td>
</tr>
<tr>
<td>2. Burning Candle Diagram:</td>
<td><img src="image" alt="Diagram" /> Convection Radiation</td>
<td>-Student does not have correct drawing of heat plume&lt;br&gt;-Student does not show that convection moves heat upward.&lt;br&gt;-Student does not show that radiation moves heat outward.</td>
</tr>
<tr>
<td>3. Fire Safety:</td>
<td>At least two fire safety rules, for example:&lt;br&gt;-low-flammability clothing like cotton&lt;br&gt;-no loose, floppy clothing&lt;br&gt;-closed toed shoes&lt;br&gt;-hair ties</td>
<td>Fewer than two safety rules were listed</td>
</tr>
</tbody>
</table>
**Lesson Overview:** Students use a physical model to learn how slope and the density of trees (or other kinds of standing fuels) affect fire spread.

**Lesson Goal:** Increase students’ understanding of wildland fire spread in forests and other kinds of standing fuels.

**Objectives:**
- Students can apply their theoretical understanding of the Fire Triangle (from Unit II) to a physical model of a forest stand.
- Students can understand how slope and density of trees (or other standing fuels) affect fire spread.
- Students can illustrate on a diagram how fire is likely to spread and why.

<table>
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<tr>
<th>Standards:</th>
<th>1st</th>
<th>2nd</th>
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<td>Weather and Climate</td>
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<td>EEEGL</td>
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<tr>
<td>Strand 1</td>
<td>A,B,C,E,F,G</td>
<td>A,B,C,E,F,G</td>
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</table>

**Teacher Background:** In this activity, students use a physical model called the “matchstick forest” to investigate two of the variables that affect the spread of wildland fire: slope and the density of trees or other standing fuels. The fuels are represented in the model by single matches. For safety’s sake, please note that the flames in this experiment can reach more than a foot in height. Plan accordingly. In addition, note that even very light breezes affect the way
matches burn in this experiment. If you are working outdoors, the demonstrations may illustrate mainly that fire spread is complex and sometimes unpredictable.

Fires tend to spread upslope, so a fire that starts at the bottom of a hill is likely to spread faster than one that starts on a hilltop (other conditions being equal). This is because:

- the fuels uphill from a fire tend to be dried and warmed by the rising heat plume
- the flames on a fire spreading uphill are quite close to the uphill fuels, while the flames are farther away from the fuels below the fire. Therefore, fuels below the fire are affected very little – at least until burning materials roll downhill and ignite new fires below.

If a fire is burning in dense forest, it may spread from treetop to treetop, that is, it may become a crown fire. In more open forests, fires are more likely to remain in the surface fuels, that is, remaining surface fires. However, surface fires tend to spread more rapidly in open than dense stands because the wind speed is usually greater in open stands.

Table 2 describes three demonstrations that can be used in this activity. We recommend that you start with Demonstration 1, which illustrates fire’s tendency to burn uphill, and then use either Demonstration 2A or 2B:

- Demonstration 2A illustrates basic principles as they apply to all kinds of plant communities subject to fire (any kind of forest, woodland, or shrubland, the world over).
- Demonstration 2B illustrates the principles as they apply to specific kinds of forest in your geographic area. In this version of FireWorks, this demonstration covers dense lodgepole pine forests, open ponderosa pine forests, and high-elevation whitebark pine forests.
<table>
<thead>
<tr>
<th>Experimental question</th>
<th>Potential hypotheses &amp; explanations</th>
<th>Experimental setup</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demo. 1:</strong> How does slope affect fire spread?</td>
<td>Fires moving uphill tend to spread faster and burn more completely than fires moving downhill. <strong>Explanation:</strong> As heat moves uphill, it dries and warms the fuels above. In addition, flames are closer to uphill fuels than to fuels on level ground.</td>
<td>Use 49 matches/board. Lay 1 board flat. Set up 2 tilted boards using two long bolts (1 bolt in each board). Ignite by lighting a full row of matches along the edge of each board: • On flat board, ignite one side. • On one tilted board, ignite the top row. • On other tilted board, ignite the bottom row.</td>
</tr>
<tr>
<td><strong>Demo. 2A:</strong> How does density of a forest stand (or other standing fuels) affect fire spread?</td>
<td>Fires generally spread faster and combustion is more complete in dense stands than in more open stands. <strong>Explanation:</strong> Heat and flames are more likely to reach fuels that are close together, drying them out and igniting them.</td>
<td>Use long bolts (to create steep slopes) for all models. Use the following matchstick densities/board (see Figure E04-1: Setup of matches for Demonstration 2A) • 49 matches • 25 matches (50%), distributed evenly • 12 matches (25%), distributed evenly • 12 matches (25%) in clusters Ignite all boards from the bottom row.</td>
</tr>
<tr>
<td><strong>Demo. 2B:</strong> How does tree density resulting from different fire histories affect fire spread?</td>
<td>Fires generally spread faster and combustion is more complete in dense forest stands, such as lodgepole pine stands that have not burned in a long time, than in more open forests, such as ponderosa pine stands that have been burned frequently. When trees occur in clusters, as in whitebark pine stands, an entire cluster may burn but the fire may not spread to others clusters. <strong>Explanation:</strong> Heat and flames are more likely to reach fuels that are close together, drying them out and igniting them. Frequent fires tend to reduce stand density by killing small trees and those of fire-sensitive species. Frequent fires also reduce fuels, both horizontally and vertically, so fires are not likely to be severe enough to kill most of the trees.</td>
<td>Use long bolts (to create steep slopes) for all models. A single board represents about 1/40 hectare, an area about 16 meters on a side. Use the following matchstick densities/board: • 49 matches to represent dense lodgepole pine stands that originated 50-100 years ago, after a severe fire • 5 matches, spaced far apart, to represent open-grown ponderosa pine stands that have experienced frequent fires • 13 matches, distributed in clusters, to represent high-elevation whitebark pine stands Ignite all boards from the bottom row.</td>
</tr>
</tbody>
</table>

*Use EITHER Demonstration 2A or 2B.*
Materials and preparation:
Do the two experiments as demonstrations. Students can help you set up the boards with the right number of matches. Ignite the matchstick forests one at a time from the bottom row of matches, so all students can observe all fires.

Choose your location carefully. If you burn indoors, be aware that the experiments can produce flames 30-40 centimeters long. Can you do this safely in your classroom and without setting off a smoke alarm? Can you take your students to a lab where it will be safer? If you burn outdoors, be prepared for variable results, since even very subtle breezes will change the fire spread pattern and may overwhelm the effects of slope and matchstick (stand) density.

- Download E04_downhill-uphill diagram.pptx to use in the assessment.
- Get plenty of wooden kitchen matches (not provided in the trunk). You will need at least 300.
- If you burn outside and it is windy, you may need to ignite with a lighter. It may be helpful to have 4-5 pieces of poster-board that students can hold at a safe distance to protect the flames from wind.
- Have fully-charged fire extinguisher handy.
- Set up your work station with this equipment (available in the trunk):
  - Two spray bottles. Fill them with water.
  - 1 metal tray (i.e., cookie sheet)
  - 1 ashtray
  - 4 masonite (“matchstick forest”) boards from the matchstick forest kit
  - Nuts and bolts from the matchstick forest kit
  - 1 pair of safety goggles
  - FireWorks safety poster (E03_FireWorks_Safety_poster.pptx from Activity E03)
- Have a metal trash can without a plastic liner nearby.
- Stop watch or clock with a second hand.
Procedure:
1. Do a safety checkup with students using the FireWorks safety poster (FireWorks_Safety_poster.pptx).

2. Explain a crown fire: A fire that moves from tree top to tree top.

3. Show students the matchstick forest model (masonite board, nuts and bolts). The board represents the ground surface; each match represents a tree or other standing fuel; the match tips represent tree crowns or other flammable fuels at the top of the standing fuel. Discuss the variables that can be investigated with this model.

4. Discuss experimental design with the class, including the principle of changing only one variable at a time to figure out cause-and-effect. Note that you’ll change only slope in Demonstration 1 and only matchstick density in Demonstration 2.

Demonstration 1 (see Table 2 above for set-up and instructions).
5. Explain: A testable prediction or guess is called a hypothesis. Ask students to offer hypotheses – that is, to predict what will happen – when each board is burned. They may have several hypotheses. Write them all on the board.

6. Assign a student to record the start time and end time of each burn. Make sure a clock showing seconds is available or have the timer use a stopwatch. (If you have a stopwatch, you don’t need the “Start time” and “End time” columns in the table below.)

7. Copy this table on the board:

<table>
<thead>
<tr>
<th>Slope</th>
<th>Start time</th>
<th>End time</th>
<th>Duration (seconds)</th>
<th>Matches burned (tree crowns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
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<td></td>
<td></td>
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<tr>
<td>Steep – burning downhill</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Steep – burning uphill</td>
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</tbody>
</table>

8. Refer to Table 2 for further instructions.

9. Dispose of burned matches in the ashtray or on the metal tray.

10. After all of three matchstick forests have burned, calculate the fire duration for each. Discuss the results. Were their hypotheses correct? Ask students to describe how the fire moved through the “tree crowns” or match heads.

Demonstration 2A or 2B (see Table 2 above for set-up and instructions). 2A focuses on the general concept of matchstick (stand) density, while 2B focuses on tree densities resulting from different fire histories in forests of the northern Rocky Mountains and North Cascades.

11. Ask for hypotheses and write them on the board.
12. Change the first column of the table on the board to reflect the three matchstick densities you will use (Table 2, Demo 2A or 2B).

13. Ignite the matchstick forests one at a time, always by igniting the bottom row of matches.

14. After all boards have burned, calculate the fire duration for each. Discuss how the fire moved through the “tree crowns” (match heads).

15. Discuss the results. Were their hypotheses correct?

16. **Clean up:** Use a metal trash can without a plastic liner. If in doubt whether fire is out, dump materials in a bucket of water before putting them in the trash.

**Assessment:** Project *E04_downhill-uphill diagram.pptx* or sketch something like it on the board. Have students explain in writing or by drawing what direction the fire would be most likely to spread and what part of the forest would be most likely to have crown fire. Have them use complete sentences to explain why.

**Evaluation:**

**Full Credit:** Student indicated that the fire is more likely to spread uphill and crown on the hillside above the flames than on flat land or below the flames. Student indicated in complete sentence(s) that trees on the slope are dried and heated by the rising heat plume, and/or fuels are closer to the flames, and/or trees are most dense on the steep section above the flame. If the student suggested that cross-slope or down-slope winds could overwhelm the effects of slope or that embers rolling downhill could start a fast-moving fire below, those answers are also valid.

**Partial Credit:** Student indicated that fire is likely to crown uphill from the flames.

**Less than Partial Credit:** Student indicated that the fire is likely to spread faster on a flat area or downhill, and/or student did not indicate understanding of how slope affects fire spread and potential for crowning.
Downhill-Uphill Diagram:
Circled area is most likely to support crown fire
Lesson Overview: In this activity, students learn that smoke from wildland fires can either disperse readily or stick around, reducing visibility on the earth’s surface and making it difficult to breathe. Then they apply health guidelines regarding smoke to a very important question: Can Physical Education (PE) Class proceed with the scheduled 1-km run, or do we need to change plans?

Lesson Goal: Increase students’ understanding of smoke from wildland fires and its potential effects on human health.

Objectives:
- Students can use information about air quality and visibility to recommend measures for protecting their own respiratory health and that of others.

<table>
<thead>
<tr>
<th>Standards:</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
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<tbody>
<tr>
<td>CCSS</td>
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<tr>
<td>Speaking and Listening</td>
<td>1,2,3,4,6</td>
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<td>Weather and Climate</td>
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<td>ESS3.B, ESS2.D</td>
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<td>Earth’s Systems: Processes that Shape Earth</td>
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<td>E,F,G</td>
<td>E,F,G</td>
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</tbody>
</table>

Teacher Background: There's no wildland fire without smoke, but the amount of smoke produced and the ways in which it disperses differ from one fire to another and even from one time to another on a single fire. If the smoke disperses upward rapidly, high-altitude winds will scatter it downwind, and the only noticeable result may be the beautiful, orange-tinged sunrise and sunset colors produced by particles in the air. However, if the smoke is trapped near the fire (by an inversion), it can make the air difficult to breathe and even difficult to see through. Smoke then becomes a health hazard, especially for anyone who has asthma or other respiratory illness, and for anyone engaging in strenuous exercise.

In this activity, students learn that smoke can disperse readily or be trapped by an inversion and why this matters. Then they use data on visibility to decide if smoke from a wildland fire may be hazardous to their health.
On most summer days, sunlight warms the earth’s surface each morning, and the air lying on the earth’s surface is heated too. This warming, expanding air rises, and its temperature decreases due to the expansion. If the air is dry, the temperature falls about 1°C for every 100-meter rise in altitude. As a result of this natural cooling, mountain tops tend to remain much cooler than valleys even on hot summer days. Because the air is constantly moving and mixing under these circumstances, we call it unstable.

Sometimes the sun doesn’t warm the earth’s surface very much during the day. Perhaps the earth is covered with snow that reflects the sunlight instead of absorbing its energy. Perhaps the cloud cover or the smoke layer from a fire is too dense to let sunlight through. When this happens, a warm layer of air rests on top of the cold air. The warm air traps the cold air on the earth’s surface. This is called an inversion because the normal daytime pattern (warm air on the bottom, cool air on top) is upside-down. The blanket of warm air lying on top of the cold air is called the inversion layer. During an inversion, the cold surface air is very stable. It cannot be dislodged until it is heated or stirred up by wind.

During an inversion, dust and other particulates in the air are trapped in the cold air at the earth’s surface. Inversions during wildland fires trap smoke. Sometimes it is so dense that you can’t see very far and the streetlights come on in the middle of the day. This much smoke interferes with breathing and is actually dangerous for babies and anyone with asthma or other respiratory illnesses. It is a good idea to limit aerobic activities and even to stay indoors until the air quality improves.

**NOTE:** This activity does not discuss inversions and how they form. If you are interested in presenting that information and demonstrating an inversion, see Middle School Lesson M09.

**Materials and preparation:**

- Download E07_smoke_slides.pptx
- Print 1 copy/student of Handout E07-1:WhatWillWeDoWithPEClass?

**Procedures:**

1. Ask students: What is smoke? Smoke consists of water, gases, and tiny particles of unburned and partially burned fuels. These are called particulates or particulate matter. The particulates are light enough to circulate in the atmosphere instead of settling immediately to earth, as larger particles do.

2. Project E07_smoke_slides.pptx. Use the handout and narrative shown at the end of this activity.
   - Slides 1-4 illustrate where smoke goes and how it can hang around for days or even weeks.
• Slides 5-10 illustrate the effect of smoke on visibility. They show a single viewpoint with different amounts of smoke.
  
  o Slide 5 explains the metric used to measure air quality: micrograms/cubic meter (mg/m³), the weight of smoke particulates of a certain size (and smaller) in a specific volume of air. PM10 is the weight of particulates 10 micrometers across and smaller. PM2.5 is the weight of particulates 2.5 micrometers across and smaller.
  
  o Slide 10 is a summary of slides 5-9. It shows the changes in visibility with 5 vs. 90 mg/m³ of PM10.

3. Ask: How does smoke affect us? Smoke reduces visibility, as the photos showed. Smoke also makes it harder to breathe as the particles get stuck inside our lungs. The particles interfere with our ability to absorb oxygen and release carbon dioxide.

4. Explain: Medical experts have provided guidelines for outdoor recreation to help us protect our lungs from smoke. Give each student a copy of **Handout E07-1: What Will We Do with PE Class?**

5. Go back to Slides 7-9. For each photo, use the handout to decide together what to do with PE class: Are these conditions OK for a soccer match? for a 1-km run? for a basketball game? How about volleyball – indoors or outdoors? If a student has asthma, should he/she have additional restrictions?

**Assessment:** Instruct the students:

1. Pair off. One of you be the school nurse, the other be the Physical Education (PE) teacher. There have been some large fires in your area recently. You look out the window, and you see that the air is smoky. You can just barely see the top of a hill 4 miles away. You had planned to have your PE class do a timed 1-km run today, but now you are not sure you should do that. Talk the situation over, use the handout, and decide what to do about PE class. Make sure your plan will take care of 3 students who have asthma.

2. Together, report to the class. Answer these questions:
   - What kinds of activities does the handout recommend for the amount of smoke in the air today?
   - What will you do in PE class today and why? If you are not going to do the scheduled 1-km run, what activities will you do instead?
   - Do you have special instructions for the students who have asthma?
### Evaluation:

<table>
<thead>
<tr>
<th>Full Credit</th>
<th>Partial Credit</th>
<th>Less than Partial Credit</th>
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<tbody>
<tr>
<td>-The student pair used information on handout to explain that visibility of four miles fits in the <strong>unhealthy</strong> health effect category.</td>
<td>-The student pair makes one or two of the following errors:</td>
<td>-The student pair did not use recommendations from handout or did not show understanding of health effects of smoke.</td>
</tr>
<tr>
<td>-The pair decided to postpone or cancel the 1-km run because it is a high-exertion activity.</td>
<td>-used the wrong health effect category or did not show understanding of health effects of smoke.</td>
<td>-The pair did not choose an appropriate activity.</td>
</tr>
<tr>
<td>-The pair chose an appropriate alternative activity*</td>
<td>-chose inappropriate activity for the health effect category chosen</td>
<td>-If they chose an outdoor activity, they did not choose an appropriate activity for asthmatic students.</td>
</tr>
<tr>
<td>If they chose an outdoor activity, they provided an indoor alternative for students who have asthma.</td>
<td>-If the pair chose an outdoor activity, they did not provide an indoor alternative for students with asthma.</td>
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*Appropriate activities:*

- If outdoors, the activities should be low-exertion and possibly short in duration. This might be an opportunity to practice kicks and footwork in soccer, pitching/batting in softball, etc. It is difficult to assess what the handout means by “prolonged periods of time,” but a 40- to 60-minute PE class is probably acceptable. However, asthmatic students cannot participate outdoors.

- If indoors, can be high-exertion and use the whole class period, and asthmatic students can participate. However, it might be good to err on the side of caution, since indoor air can become quite polluted when outdoor smoke concentrations are high.

- A classroom lesson or activity, perhaps something related to health or diet, might be a good alternative – especially if the gym is not available.
Handout E07-1: What Will We Do with PE Class?

Decision making recommendations during wildfire season for

Outdoor Sporting Events
based on visibility and air quality

<table>
<thead>
<tr>
<th>Health Effect Category*</th>
<th>Visibility</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>13.4 miles and up</td>
<td>Hold outdoor sporting events as usual. Athletes with asthma should keep rescue inhalers readily available and pretreat before exercise as directed by their healthcare provider. All athletes with respiratory illness should limit outdoor activity, monitor symptoms and reduce/cease activity if symptoms arise.</td>
</tr>
<tr>
<td>Moderate/Unhealthy for Sensitive Groups</td>
<td>5.1 to 13.3 miles</td>
<td>Hold outdoor sporting events as usual. Athletes with asthma should have rescue inhalers readily available and pretreat before exercise as directed by their healthcare provider. All athletes with respiratory illness should limit outdoor activity, monitor symptoms and reduce/cease activity if symptoms arise.</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>2.2 to 5.0 miles</td>
<td>Consider postponing/delaying outdoor sporting events, especially high exertion activities like soccer and track and field. If possible, move athletic practices indoors. If event/practice is held, athletes with asthma or other respiratory illnesses are advised not to participate. All athletes should limit their outdoor activity for prolonged periods of time.</td>
</tr>
<tr>
<td>Very Unhealthy</td>
<td>1.3 to 2.1 miles</td>
<td>Consider postponing/delaying all outdoor sporting events. Move all athletic practices indoors. All athletes with asthma and other respiratory illnesses are advised to stay indoors. All others should avoid prolonged exertion outdoors.</td>
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<tr>
<td>Hazardous</td>
<td>1.3 miles or less</td>
<td>Cancel all outdoor sporting events or relocate to an indoor location. Move all athletic practices indoors.</td>
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At all times, athletes experiencing respiratory symptoms should consult their personal healthcare provider.

*Visibility: How far can you see? To figure this out:
1. Face away from the sun.
2. Look for landmarks at a known distance from you.
3. If you can’t see a landmark, then you know that visibility is less than that distance.

Source: [http://www.missoulacounty.us/home/showdocument?id=5543](http://www.missoulacounty.us/home/showdocument?id=5543)
Lesson Overview: In this activity, students examine botanical specimens of tree species and learn to use a dichotomous key to identify them.

Lesson Goal: Students will understand that tree species are diverse and one can identify trees by looking at them carefully.

Objectives:
- Students will be given a set of biological specimens.
- Students can use a key to determine the species of each one.

### Standards:

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<tr>
<th>Common Core ELA</th>
<th>1st</th>
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<th>3rd</th>
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<td>4</td>
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<td><strong>Language Standards</strong></td>
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<td><strong>Information Processing</strong></td>
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<td><strong>Inheritance/Variation of</strong></td>
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<td><strong>Organisms and Ecosystems</strong></td>
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<td><strong>LS4.C</strong></td>
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<td><strong>C</strong></td>
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**Teacher Background:** A wildland ecosystem is characterized by diversity, and the diversity of tree species is an important characteristic of forests. To understand the complexity of fire’s role in forests, students must be able to distinguish among tree species. In this activity, they learn how to use a dichotomous key to identify ten of the important trees in the northern Rocky Mountains and North Cascade range.

This activity requires reading skill. For early elementary students, select a few species and do the activity together as a class by reading questions from the key (using the PowerPoint
presentation) and having students look at the specimens, answer the questions, and thus decide on the correct species.

For students with greater reading skill, use the PowerPoint presentation to demonstrate how to use the key, and identify one species together with the class. Then have each student or group of students visit nine stations, each with a set of specimens (bark, foliage, flowers or cones, and photographs from one species). All specimens are labeled with a code letter for that species. Students will circulate from one station to another, examining the specimens, using the key to determine the species of each, and recording the code letter for that species on the handout.

Code letters for the trees in this version of FireWorks are:

- Black cottonwood B
- Douglas-fir V
- Engelmann spruce H
- Lodgepole pine E
- Ponderosa pine O
- Quaking aspen L
- Subalpine fir C
- Western larch T
- Western redcedar D (This is the example species in the presentation.)
- Whitebark pine J

The dichotomous key in Handout E10 can also be used in the field, so this activity can prepare students for a field trip. If you want to test their knowledge in the field, find an area with several of these tree species represented, label the trees with the letter codes here, and have students fill in the handout as they move from tree to tree.

Note that this key will not work in winter.

**Materials and preparation:**

- Print a copy of **Handout E10. Identify 10 summer trees!** (two pages – print 2-sided, if possible) for each student.
- Download presentation **HowToUseKey.pptx**
- Assemble 10 stations in the classroom, each one containing the following for a species:
  - Tree bark/trunk specimen (in trunk)
  - Cone or flower specimen (in trunk)
  - Foliage specimen (in trunk)
  - Photos of the species (in trunk and by download)
  - Keep the specimens for species D (western redcedar) at your desk.

The Mystery Trees box in the trunk contains labels with the species names. Do not display these with the specimens.
Procedure:
1. Explain: We will identify several local tree species today by using a key. When you have this skill, you’ll be able to take your key to a local forest and identify many of the trees there. We’ll identify one species together, and then you will do the rest at nine stations.
2. Give each student a copy of Handout 4.
3. Open the PowerPoint presentation. Starting at the upper left corner of the key, work with the students to see how a tree gets identified based on characteristics such as leaves, bark, cones or flowers, etc. Make sure they use the descriptions on the back of the handout to confirm their identification. (If they are in the field, there may be additional tree species and they’ll need the extra clues to make a correct identification.) Have them enter “D” in the correct place on the handout.

Assessment:
Have students circulate from one station to another (order doesn’t matter), identify the tree species at each station, and enter the correct code letter in the handout.

Evaluation:

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<th>Full Credit</th>
<th>Partial Credit</th>
<th>Less than Partial Credit</th>
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<tbody>
<tr>
<td>-Student correctly identified 6-10 species</td>
<td>-Student correctly identified 2-5 species</td>
<td>-Student correctly identified less than 2 species</td>
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October 5, 2017
Handout E10-page 1. Identify 10 summer trees!

Name ____________________

- Does it have needle-shaped leaves? yes
- Are the leaves a lot shorter than your thumb? yes
- Is the bark smooth? yes
- Whitebark pine?
- Are the leaves tiny, looking like overlapping scales? no
- Western redcedar? yes
- Quaking aspen? no
- Black cottonwood?
- Are the needles in clusters of 2? yes
- Lodgepole pine?
- Are the needles generally in clusters of 3? no
- Ponderosa pine?
- Are the leaves a lot shorter than your thumb? no
- Subalpine fir?
- Western larch?
- Are the cones hang down from the branches? no
- Do the cones have a lot of 3-pointed, papery things coming out from under the scales? yes
- Engelmann spruce?
- Do its needles grow in bundles on little woody bumps? no
- Do the cones hang down from the branches? yes
- Douglas-fir?
- Are the cones have a lot of 3-pointed, papery things coming out from under the scales? no
- Western redcedar?

This key works best for mature trees. Use it to make a good guess at what kind of tree it is. Then read the notes on the back to check your guess. It could be a different species!

*Needles are a special kind of leaf.
Handout E10-page 2. Check your tree identification:

1. **Black cottonwoods** have wide leaves that may be very shiny. The buds at the ends of their twigs re pointy and, in spring, they are very sticky. Old cottonwoods have gray, deeply furrowed bark. Cottonwood seeds are packaged with lots of cottony fluff, which helps them float on wind and water.

2. **Douglas-firs** have short, flat needles and brown, furrowed bark. The buds at the ends of their twigs are pointy. Their cones feel kind of papery (like spruce cones) but with this difference: Little, 3-pointed “wings” stick out from under the cone scales. It looks like tiny mice are trying to burrow in, but they can’t hide completely!

3. **Engelmann spruces** have short needles with very sharp tips, which gives them the name “Sticky Spruce.” Their cones feel kind of papery. Their bark is grayish, with roundish scales that sometimes flake off.

4. **Lodgepole pines** have fairly long needles that usually grow from the twig in clusters of 2. Their cones are pointy and very prickly. Sometimes their cones are closed tight so the seeds can’t get out. Their bark is dark and scaly.

5. **Ponderosa pines** have long needles that usually grow from the twig in clusters of 3. Their cones are prickly. Sometimes their cones are closed tight so the seeds can’t get out. Their bark is dark and scaly.

6. **Quaking aspens** have roundish leaves with a pointed tip. Their leaves move almost constantly because they are very sensitive to wind. Their bark is mostly grayish-white and smooth, although old trees can have furrowed bark down near the ground. Their seeds are packaged with cottony fluff that helps them float on wind and water.

7. **Subalpine firs** have short, flat needles and gray bark. Their bark often looks like it has spots or blisters in it. Their cones grow at the very tops of the trees, pointing upward toward the sky. The cones don’t fall off. Instead, they fall apart on the tree, and the pieces fall to the ground.

8. **Western larches** have short, soft needles, which grow in tufts out of little woody bumps on the twigs. Their leaves turn gold in the autumn and then fall off. Therefore, they are conifers (cone bearers) but not evergreens like pines, firs, and spruces. Western larch cones are small and lightweight. The tree’s bark is brown to reddish-brown.

9. **Western redcedars** have leaves that look like tiny, overlapping scales. Because many leaves grow together, the trees may look a little like they have small ferns for leaves. Their cones are small —about as big across as your thumbnail. Western redcedar bark is grayish, with furrows and loose strands. It looks like someone tried to peel or shred the bark.

10. **Whitebark pines** have fairly long needles that grow from the twig in clusters of 5. Their cones are purplish-brown. They don’t usually fall off the tree. Most of them ripen in the treetops and then get pulled apart by Clark’s nutcrackers, who want their large seeds. The pieces of cone that the nutcrackers remove fall to the ground under the tree. Whitebark pine’s bark is whitish on young trees but gray to black on older trees.
Identify 10 summer trees!

This key works best for mature trees. Use it to make a good guess at what kind of tree it is. Then read the notes on the back to check your guess. It could be a different species!

*Needles are a special kind of leaf.