WEATHER IN YOUR POCKET

SUBJECTS: English/Language Arts, Science, Meteorology, Health

GRADES: 4-12

DURATION: One 45-60 minute class period

GROUP SIZE: One class

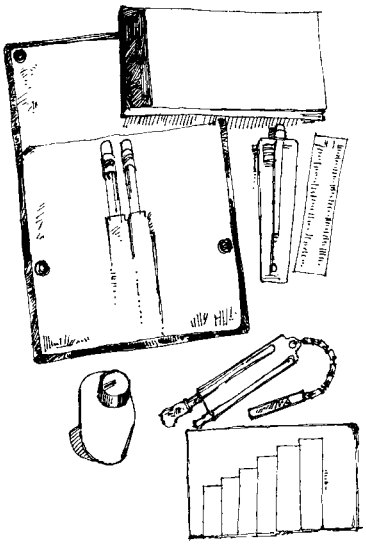
SETTING: Outdoors in an open area

KEY VOCABULARY: Anemometer, psychrometer, relative humidity, dry-bulb temperature, wet-bulb temperature

ANTICIPATORY SET: Changing weather determines potential fire danger. Today you will learn to use specialized equipment to determine current weather conditions.

OBJECTIVES: Students will become familiar with the parts of a belt weather kit and be able to measure relative humidity, calculate wind speed, take dry-bulb and wet-bulb temperature readings, use a compass, and compute the rate of fire spread.

MATERIALS: Belt weather kit (containing an anemometer, psychrometer, compass, writing board, water bottle, and humidity tables) and Fire-Weather Observer's Record sheets



BACKGROUND:
Changing weather changes fire's potential to burn. The weather becomes a top priority for both firefighters calculating the safest day to conduct a prescribed burn and/or for forest managers determining the potential for a fire to occur on a specific woodland. A shift of wind direction or a drop in relative humidity can indicate an increase (a blow-up) of fire activity. How can firefighters best prepare for weather changes if they're working several miles from their base camp?

As you learned in the previous lesson: The intensity of fire and the rate with which it spreads is directly related to the wind speed, temperature, and relative humidity. The person fighting a fire needs to know what to expect. Has the humidity in the air increased with a welcoming rain or snowstorm that will help put out this fire? Has the wind speed or wind direction changed? Could the flames be blown towards me? Could I safely move in this direction?

To help answer these questions, wildland firefighters will use a portable weather station that is small enough to attach to their belt or to be carried in their fire pack. By including a compass, an anemometer, and a psychrometer, this weather kit contains all the instruments necessary to answer these important questions.

Most wildland firefighters are working in unfamiliar territory. This may be the first time they have ever seen this particular forest, mountaintop, or state! To help orient them to the local terrain, the belt weather kit contains a compass. When used in conjunction with a local map, the firefighter can anticipate and plan for nearby situations. Maps can show safe routes away from the fire, potential hazards (such as a steep cliff or deep gully), or even natural firebreaks that can be used to slow or even stop a fire's progress (such as a river, road, or pond). The compass prevents the firefighter from getting lost in woods thick with smoke and soot.

The compass can also be used to indicate the aspect or the direction in which a slope faces. The aspect of a slope generally determines the amount of heat the ground gets from the sun. South and southwest slopes are normally more exposed to sunlight and therefore the ground would normally be hotter. Because of the higher temperatures, the air would have lower humidity and fuels found there would have lower moisture levels. These

slopes are the most critical for the start and spread of wildfires. Shaded north-facing aspects (or slopes) typically have heavier fuels, lower temperatures, higher humidity, and higher fuel moisture levels.

An anemometer measures wind speed. Winds influence fires in several ways. As you learned from the lesson on the fire triangle, fire requires a combination of fuels, oxygen, and heat in order to burn. Winds assist all three components of the fire triangle, making it more difficult to contain a fire in windy conditions. First, winds encourage combustion by increasing the supply of **oxygen** to the flames. As a fire burns it will consume oxygen from the air. Winds carry a fresh supply of oxygen to the flame, thus feeding the flames. Winds will dry out **fuels** ahead of the flames. As winds blow across downed wood or across dead grasses, moisture held in these fuels will be pulled out into the air. As fuels loose moisture they become easier to ignite. Thus winds encourage the spread of fire by providing dry, consumable fuels. Winds can bend the flames over until they are almost horizontal, thus pushing them closer to their potential fuels. Or, through convection, heated air can be pushed ahead of the flames towards downwind fuels. Both cases will bring the **heat** closer to the fuel source, helping to dry the fuels in front of the fire, and putting the ignition spark closer to the fuels. Because of this pushing force against the fire front, winds begin to influence the direction of the fire's spread. Firefighters hope the winds blow the flames towards natural firebreaks such as roads, rivers, or lakes, but more often winds blow the flames towards new patches of dry, combustible fuels. Winds can also carry sparks from the main fire to new locations as far as 10 miles away! Winds are thus responsible for starting new fires and starting fires on many fronts simultaneously. When these new "spot fires" are great distances from the main fire it can definitely stretch the resources available for fighting a fire! Knowing the direction and speed of winds help firefighters plan their strategy.

A psychrometer is used for measuring the temperature and relative humidity. Temperature is a measurement of the warmth or coldness of a substance. The higher the ground or fuel temperature, the easier it is for the fuel to ignite and burn. The higher the air temperature, the faster fuels will dry and become easier to ignite. Fuels exposed to the sun can be as much as 50 degrees hotter then the same fuels lying in the shade! Because the sun controls the earth's temperature, firefighters measure the air temperature in order to predict fire potential.

Relative humidity is a ratio of the amount of moisture in the air compared to the amount which the air could hold at the same temperature and pressure if it were saturated. Relative humidity is usually expressed as a percentage. The relative humidity is important because dead forest fuels and the air constantly exchange moisture. During periods of low humidity the air pulls moisture from the fuels. During periods of high humidity (think of rain), moisture is absorbed by the fuels. Light fuels (such as grass) will lose moisture quickly during changes in relative humidity. This change in moisture can happen in as little as an hour! Heavy fuels (such as fallen tree trunks) have a much slower exchange of moisture with the surrounding air. For heavy fuels, it may take several weeks to change their moisture level.

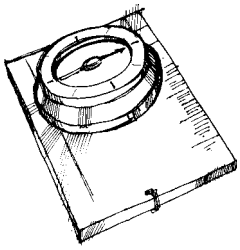
In this lesson, students will have a chance to examine the weather around them. What is the potential for fires to spread on the day of your measurements?

PROCEDURE:

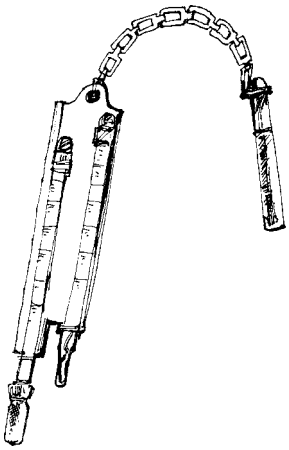
1. Assemble the class outdoors. Have students work in small groups. Give each group a belt weather kit, one copy of the Fire-Weather Observer's Record and a pencil.

2. Direct students to complete the top section of the form as a group. On the first line, they should fill in their **location** (school yard, outdoor classroom, or city name); today's **date**; and the **name(s)** of everyone in their group. On the second line they should fill in the **exposure** (ridgetop, hillside, forest, field, etc.); and **elevation** (on average, the highest locations in south-central Kentucky are approximately 800 feet above sea level). Leave the **aspect** blank for now. Aspect is the direction the land is sloped. Students may circle the aspect after they learn to use their compass.

3. Have the class take out their compass from pocket number 7 of their belt weather kit. Explain that the compass can be used to show directions (north, south, east, or west as well as points in between), it can be used to locate items shown on a map or help you travel through unknown terrain (orienteering), and today it will be used to help determine the weather!



4. To determine the aspect, have students examine their compass. A bottom rectangle of clear plastic has a ruler along the top edge. Facing the ruler is an arrow that says "Direction of travel". Students should hold their compass close to their chest with this direction of travel arrow pointing directly in front of them. The compass needs to be kept horizontal so that the red needle inside the circular compass housing can move freely. Have the students stand facing a distant landmark so that their back is to the slope of the hill (or with their back to the school if the schoolyard is on flat land). Without changing the position of their compass, have the students turn the housing only (the round part of the compass that has numbers from 1-360) until the floating red needle is directly over the drawn arrow, with the red end of the needle pointing to the "N" (north) painted on the edge of the housing. Now look at the letters and numbers on the round housing. The line between "Direction" and "of travel" is your index pointer. For younger children, have them look for the magnetic direction letters (N, S, E, or W) on or near this line. That will be your direction of aspect. You may require older children to record both the direction and the number of degrees indicated.



5. Now circle the **aspect** or direction the land is sloped (i.e., circle "S" if slope is facing south, or write "flat" if the schoolyard has no observable slope).

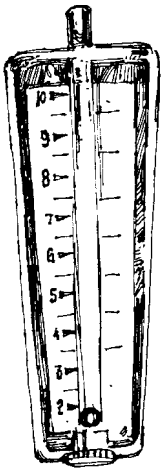
6. Show the class the psychrometer located in pocket number 3 of the belt weather kit. Explain that the psychrometer hangs from a chain attached to a metal bar which the students will hold tightly at all times. Caution the children to handle this instrument carefully so they do not break the two thermometers which extend below the metal casing. The two thermometers will take a "dry bulb" reading and a "wet bulb" reading. The "wet bulb" thermometer is the one with a white stocking (wick) attached to the end of the thermometer. These two temperature readings will give us not only the air temperature, but will also give us the relative humidity and dew point readings.

7. First have the children take the dry bulb temperature reading. To do this, have them stand in the shade, face the wind, and hold their psychrometer in front of them until the thermometer reachs equilibrium (2-3 minutes). Read the temperature and record this number in the appropriate column.

8. Have the students find the small bottle of water located in pocket number 5 of the belt weather kit. Instruct them to open the bottle and dip the white cloth tipped thermometer into the water until the wick is saturated. Holding the metal handle tightly at arms length, the students should whirl the psychrometer at a moderate rate for 30-60 seconds. The whirling motion is similar to the rotation of an airplane propeller. Read and record the temperature on the wet-bulb thermometer in the appropriate column.

9. To calculate the relative humidity, have the students open the "Relative Humidity and Dew Point Table" found in the belt weather kit pocket number 1. Have the students find their dry bulb temperature located down the left-hand side of the columns. Next, have them locate their wet bulb temperature listed across the top of the table. If they look at the intersection of these two columns they will find the relative humidity listed as a black number. This number should be written under the appropriate column on their form and shown as a percentage (%). The potential for a wildland fire increases as the relative humidity decreases and becomes most threatening if the relative humidity reaches10% or less. Based on today's relative humidity reading, is the fire threat high or low today? Is this a good or bad day to conduct a prescribed burn? NOTE: The red number in that same intersecting block tells the dew point – or the temperature (in degrees Fahrenheit) at which the moisture in the air will condense to form a layer of dew on the ground. Ask the students why they think dew only forms in the early morning hours? Would finding a layer of ground moisture in the morning assist or hinder a firefighter with his duties?

10. Show the class the anemometer found in pocket number 2 of the belt weather kit. Explain that this instrument is used to measure the wind speed. Turn so the wind is blowing into your face. Hold the anemometer vertically with the red scale facing you. Watch the small white ball move up the scale. The height of the ball indicates the wind velocity in miles-per-hour. Sometimes the white ball in your anemometer will remain fairly stable but suddenly rise rapidly only to fall back to the original level. This would be an indication that you are experiencing wind gusts. Record wind speed in the appropriate column. Record wind gusts under the "Characteristics & Comments" column. Strong winds and/or the presence of wind gusts increase the potential for fires to spread. Based on your readings, should a farmer burn his fields today? Is this a good day for you to burn a pile of leaves?



11. Using your compass, calculate the wind direction. Wind direction is determined by the direction from which the wind is blowing. For example, a north wind means the wind is blowing from the north. Stand facing the wind. Using your compass, find what direction you are facing. Record the direction on your worksheet. If you were fighting a fire, which side of the fire would you stand on today based on your wind readings? Why?

12. Under "Characteristics and Comments", you can indicate the speed of wind gusts; whether the sky is clear, foggy, or cloudy; or whether the day is sunny, raining, or snowing.

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CLOSURE: When land managers consider conducting a prescribed burn they first look at the weather. Changing weather can spell danger to a wildland firefighter. A shift of wind direction or a drop in relative humidity can indicate an increase (a blow-up) of fire activity. Today you have learned how to gather weather information even if you're busy fighting a fire in a remote wilderness area.

EVALUATION: Teachers will be able to evaluate the worksheets produced by the class. Teachers will be able to observe student's ability to follow directions and their ability to cooperate with each other in their small group settings.

EXTENSIONS:

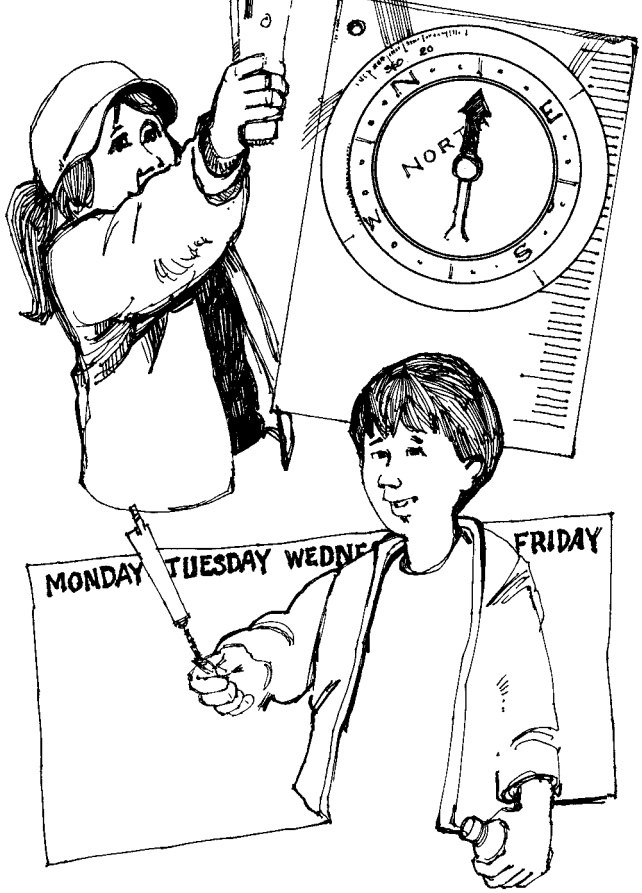
1. Have students compare the air temperature with ground and fuel temperatures. Place a thermometer on the ground in the sun. Place a second thermometer on the ground in the shade. Are these temperatures the same or different? Take temperature readings under a leaf pile; in a parked vehicle; under a log; under a black cloth and under a white cloth; on the north and south sides of a hill. Are all the temperature readings the same? Why or why not?

2. Have the students repeat their weather readings every 15 minutes until the end of class. Were there any noticeable shifts in wind direction/speed or changes in humidity or temperature readings during this time period?

3. Have students repeat their weather readings during the day. Did they notice a pattern to the rises or falls in wind, humidity, or temperature? Have students graph their results.

4. Have students repeat their weather readings at the same time every day for a week. Did they notice changes? Compare student's results with the "official" weather summary found in the newspaper or on the Internet. Are they the same, similar, or very different? If different, what could cause the irregularity? Have students find the location of their "official" weather station. Is it close to their school or many miles away? Are there topographic features that might cause different readings?

5. Plan a field trip to a near-by weather station or have a local meteorologist visit your classroom to discuss weather monitoring with your students.



FIRE WEATHER OBSERVER'S RECORD

Fire-Weather Observer's Report

Date	Location	Name(s)

Exposure	Elevation	Aspect
		N E S W Flat

Time	Temperature		Relative Humidity *(%)*	Wind		Characteristics & Comments
	Dry	Wet		Speed *(m.p.h.)*	Direction *(from)*	