TOPIC: Wildland Fire Behavior - Weather

TIME FRAME: 4 Hours

LEVEL OF INSTRUCTION:

BEHAVIORAL OBJECTIVE:

Condition: A written quiz

Behavior: The student will list and describe the elements of weather as they affect wildland firefighting.

Standard: With a minimum of 70% accuracy

MATERIALS NEEDED:

- Appropriate visual aids
- Audio visual equipment

REFERENCES:

- Wildland Firefighting, Clayton, Day, McFadden, Chapter 2
- USDA, Forest Service, Fire Weather, Agriculture Handbook 360
- The Humidity Business, Countryman

PREPARATION: Weather is the largest single contributing factor in vegetation fires. Every member of a fire crew must know basic weather so they can anticipate changes in fire behavior and act accordingly to assure their own safety.

PRESENTATION	APPLICATION

I. INTRODUCTION

A. Weather

1. A key determinant of fire behavior

2. Especially of rapid changes in fire behavior

B. Information on the Weather is Available from Several Sources

1. The long-term trends of moisture and temperature that have been experienced

2. Daily forecasts of fire weather broadcast by the E.C.C.

3. Specific forecasts accompanying incident action plans, or spot weather forecasts

4. Reports from lookouts or stations

5. Local indications that can be seen or felt

6. Local T.V. or radio stations

C. Terms Commonly Used to Describe the State of the Weather

1. Temperature

a. Measures the average energy of air molecules, using a thermometer not exposed to direct sunlight

(1) Temperature influences relative humidity and fuel temperature

(2) Air that is warmer than surrounding air is less dense and therefore tends to rise

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(3) Air that is cooler than the surrounding air is denser and tends to sink

2. Relative Humidity (R.H.)

a. The ratio expressed as a percentage

b. Of the amount of moisture present in a volume of air, compared to the total amount of moisture which that volume of air can hold at the given temperature and atmospheric pressure

c. In the short term the actual concentration of water vapor in the air varies little

d. As temperature varies the maximum amount of water vapor that could be present varies, changing the relative humidity

e. For a constant actual concentration of water vapor:

(1) As temperature increases by 20oF the relative humidity is cut in half

(2) As the temperature decreases by 20oF the relative humidity is doubled

f. Minimum relative humidity usually occurs with the afternoon high temperature; maximum relative humidity usually occurs with the early morning low temperature

g. Relative humidity is the main determinant of the moisture in dead fuels (such as grass or dead needles)

3. Dew Point

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a. It is the temperature to which air must be cooled to produce condensation of water droplets	
4. Barometric Pressure	
a. Measures the air pressure at a given point due to the force exerted downward by the overlying column of air	
(1) As air rises it is subjected to decreasing pressure, it expands, and it cools	
(2) As air sinks it is subjected to increasing pressure, it is compressed, and it warms	
(3) Wind is driven by horizontal differences in barometric pressure, from areas of higher pressure to areas of lower pressure	
5. Wind	
a. The movement of air more or less parallel to the surface of the earth	The standard measurement height is 20'
(1) Wind speed is commonly expressed in miles/hour, knots, or meters/second	
(2) Wind speeds can be estimated using the modified Beaufort Scale	The standard measurement height is 20'.

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b. Wind direction is the direction from which it blows when expressed as a compass direction (for example, a northwest wind is blowing from the north west).	
c. Wind direction is the direction to which it blows when referenced to the terrain (for example an up canyon wind blows toward the upper end of the canyon)	
d. Downdraft and updraft refers to air currents moving vertically	
II. GENERAL WINDS	
A. General winds are those that are driven by large-scale pressure systems	
1. Air moves from areas of high pressure to areas of low pressure, along gently curved paths (due to deflection by the earth's rotation)	Information sheet #1 Figure #1
2. General winds are broad-scale, being similar in direction and speed over major portions of a state or several states	
3. General winds patterns commonly persist over periods of several days	
B. The Prevailing Pressure Pattern and Associated Direction of General Winds is a Good Indicator of the Weather Conditions They Bring	
1. High pressure systems or ridges are associated with:	
a. Clear skies, though low-level haze may occur	
b. Lower humidity	

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c. Higher temperatures	
d. Winds with a northerly component (usually blowing from between NW and NE	
e. Reduced marine layer	
2. Low pressure systems or troughs are associated with	
a. Increasing chance for clouds and possible precipitation	
b. Higher humidity	
c. Lower temperatures	
d. Winds with a southerly component (usually blowing from between SW and SE)	
e. Thickened marine layer	
f. Possibility of cold front passage	
C. A Front is the Zone Separating Air Masses of Differing Properties	
1. In warm fronts, warmer air follows cooler air; they are rarely of any consequence to fire weather in the western U.S.	Information sheet #1 Figure #2
2. In cold fronts, cooler air follows warmer air; they can produce sudden and important changes	Information sheet #1 Figure #3

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a. Air behind the front is usually drier	
b. Wind direction will shift clockwise by roughly 90o	
c. Wind speeds may increase significantly, often remaining higher for a day or two	
III. CONVECTIVE WINDS	
A. Driven by Air Temperature Differences Brought On by Differential Heating or Cooling of the Land or Water Surface	
1. They commonly follow a daily cycle	
2. A particular convective wind system affects areas ranging in scale from a single slope to major valleys and mountain ranges	
B. Sea-Land Wind System	
	Information sheet #2 Figure #4
1. Land in the coastal zone is warmed by the sun while the ocean remains cool; warmed air rises, causing a "sea breeze" to flow on shore.	
a. Onshore flow usually brings cool, moist marine air	
b. The marine air often moves in as a small scale cold front, and it can bring winds that fan the fire before increasing moisture can affect the fuels	
c. Cool marine air flowing on shore can spill into interior valleys, producing downslope winds in the afternoon	

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(1) The Great Valley is not usually affected that way unless the marine layer is quite deep	
C. Slope-Valley Wind System	
1. Sunlit slopes warm the air causing it to rise and flow up the slope	
	Information sheet #2 Figure #5
a. Early in the day the winds are predominantly upslope	
b. By midday winds blow up the major canyons	
c. By afternoon winds blow up the larger valleys, often producing winds across the ridges that differ from those blowing up the canyons	
2. As slopes become shaded in the evening and cool throughout the night, air near the ground flows down slopes and drainages	
a. Downslope flow is usually slower and smoother than the daytime upslope wind	
b. Cool, denser air is strongly channeled by the terrain, flowing down-drainage	
D. Whirlwinds	
1. There are two essential ingredients required to make a whirl	
	Information sheet #2 Figure #6
a. A strong updraft	

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(1) Such as that produced by fire or strong solar heating of the ground	
(2) Surrounding air will flow toward the rising current of air	
(3) Whirls are common over the fire area due to the fire's heat and/or solar heating of blackened ground	
b. Rotation or swirling motions in the inflowing air	
(1) The rotation is intensified as the air moves in toward the updraft	
(2) Wind flowing around topographic obstacles, buildings, or trees can create the swirling motions required to trigger a whirl	
(3) The turbulent air flow on the downwind (lee) side of major ridges is a favored location for whirls	
E. Thunderstorm Winds	
1. Downdrafts are generated in the core of well-developed thunderstorms	
	Information sheet #3
a. Downward drag of falling precipitation	
b. Evaporation from raindrops cools air through which it falls	
2. Dense cold air spreads out when it reaches the surface	
a. Can create sudden, strong winds	

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(1) Generally from the direction of the storm, and

(2) Stronger on the downwind side of the storm

b. Often channeled by terrain

(1) Can reverse normal upcanyon winds

c. Effects can spread miles from the parent thunderstorm

d. Commonly decline somewhat a few minutes after they hit

(1) Groups of active thunderstorms can produce winds that last several hours

F. Anticipate the Local Convective Wind Systems

1. Observe dust, smoke, flags, etc.

2. Note reports from stations or other observers located below the highest points (The highest points will usually feel the general winds more strongly than local winds)

3. Observe several times during the day to learn how wind speeds and directions change in the daily pattern

4. Note the relationship of local convective winds to the existing general winds

IV. WIND INTERACTIONS

A. The Wind that Influences a Given Location Can be Thought of as the Combined Effects of the Prevailing General Winds and Convective Winds; Topography can Further Modify Low Level Winds.

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B. The Wind System that is Dominant is often Dependent upon Topographic Location

1. Higher elevations, and prominent points such as major peaks and ridges tend to be more under the influence of the general winds

2. Convective wind systems tend to have their greatest influence on lower and less exposed locations such as canyons and lower slopes

3. Wind direction and speed can vary greatly throughout the range of elevations from the bottom of a drainage to the surrounding high points

C. The Influence of the General Wind at the Ground is Largely Determined by Vertical Mixing of the Air

1. When the air near the ground remains unmixed with air aloft then the general winds will slip along above with very little affect on the ground

2. On a typical sunny day rising warm air and compensating sinking air will create a well mixed layer that deepens progressively (up to 2000 or 3000 feet depths)

3. The influence of the wind aloft can be brought down to the surface

   a. Sudden changes in speed and/or direction are possible

   b. Where general winds align with convective winds abnormally high winds can result

4. Watch the smoke column for evidence of winds above the surface

   a. The closer the winds are to the ground, the sooner they might surface

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b. The more active is the mixing process (as on a hot clear day with unstable air) the sooner they might surface

5. Winds aloft may not surface at all, or strengthening convective winds may eventually "overpower" a general wind that has surfaced

6. Night time cooling stops convective mixing in the near-surface air

a. The winds affecting slopes and drainage bottoms can cease abruptly, becoming downslope winds

b. General winds, freed of drag against the earths surface, can even increase in velocity and can blow hard on exposed parts of the terrain

D. Topography and Other Obstacles Modify the Wind Felt at the Ground

1. Wind deep in a drainage is strongly channelled, up or down canyon

2. Wind is often accelerated as it passes over long ridges or through saddles

3. Turbulence can cause gusty, erratic winds along canyon sides and on the lee side of ridges, or downwind of trees or buildings

4. A tree canopy will greatly reduce the velocity of winds acting at the surface

V. FOEHN WINDS

A. Foehn Winds Common to California include:

1. Santa Ana winds in Southern California

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2. North or Mono winds in the Cascades and Sierra west slope	
3. East winds in the Coast Ranges	
B. Three Things are Essential to the Production of Strong Foehn Winds:	
1. A major ridge or mountain range oriented more or less perpendicular to the wind direction, with a steep, largely unbroken lee slope	
2. A large barometric pressure difference across the mountains to drive strong winds	
3. Stable air at mountain top level, that will flow in large waves when it moves downstream of the mountain crest	
C. Weather Conditions often Associated with the Development of Foehn Winds in Fire-prone Areas of California	
1. High pressure in the Great Basin area (or Pacific Northwest)	
2. Low pressure off the California coast (or in the Sacramento Valley)	
3. Winds blowing from directions between north and east	
4. More common in spring or fall than in summer	
D. Fire Weather Forecasts are Fairly Reliable in Forecasting the Development of Foehn Conditions	
E. Onshore and Offshore Flow of Marine Air can Greatly Alter the Effects of the Foehn Winds at the Ground in Coastal Zones	
1. Onshore flow may cause a weak foehn wind to remain aloft during the day	

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2. Offshore flow and cooling of the air may cause a foehn wind to surface at night or strengthen an existing foehn wind; such winds are sometimes called "sundowners"	
3. Watch the smoke column during the day for evidence of winds aloft blowing offshore that could surface later on	
F. Effects of Foehn Winds	
1. Extremely high wind speeds, often greatest in mountain passes or canyons	
2. Very dry, warm air and low relative humidities	
G. Downslope Winds, in Many Respects like the Major Foehn Winds, can Develop when Denser Air from the Coast Spills Down Slopes into Inland Valleys	
1. Such Winds Commonly Occur in the Afternoon	
2. In Response to Heating of the Interior Areas	
3. Producing a Reversal of Normal Afternoon Upslope Wind	
VI. INVERSIONS	
A. An Inversion is a Layer of Air within which Temperature Increases with Height	
1. Cool marine air often underlies warmer air, a "marine" or "coastal" inversion	Information sheet #4
2. Inversions resist the motion of currents rising from below, causing them to spread out	
3. Cool air can settle into or be retained in canyons, valleys and basins with warmer air on	

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top - a common nightly occurrence ("night inversion") 4. Air subsiding in a high pressure system can warm up more than the underlying air forming a "subsidence inversion" B. Wind At or Above the Inversion is Often Stronger and from a Different Direction Than Any Wind Below the Inversion C. Erosion or Dissipation of Inversions 1. Daily warming of the cool air eventually eliminates low level inversions over land 2. Wind above the inversion helps to mix air and eliminate the inversion 3. Removal of the inversion can affect fire behavior a. Allowing the establishment of a better developed convection column b. Mixing down the effects of inversion-level winds and/or drier air from aloft c. Clearing smoke to allow accelerated heating and drying of fuels, and the more effective transfer of heat by radiation	

SUMMARY:

Weather plays a key role in how a fire burns. Temperature, humidity and wind are weather factors the firefighter must monitor on a daily basis "throughout the day". Personnel familiar with weather conditions can prepare for fire behavior and hopefully avoid a surprise that would endanger themselves or their crew.

EVALUATION:

A written quiz.

ASSIGNMENT:

To be determined by instructor(s).