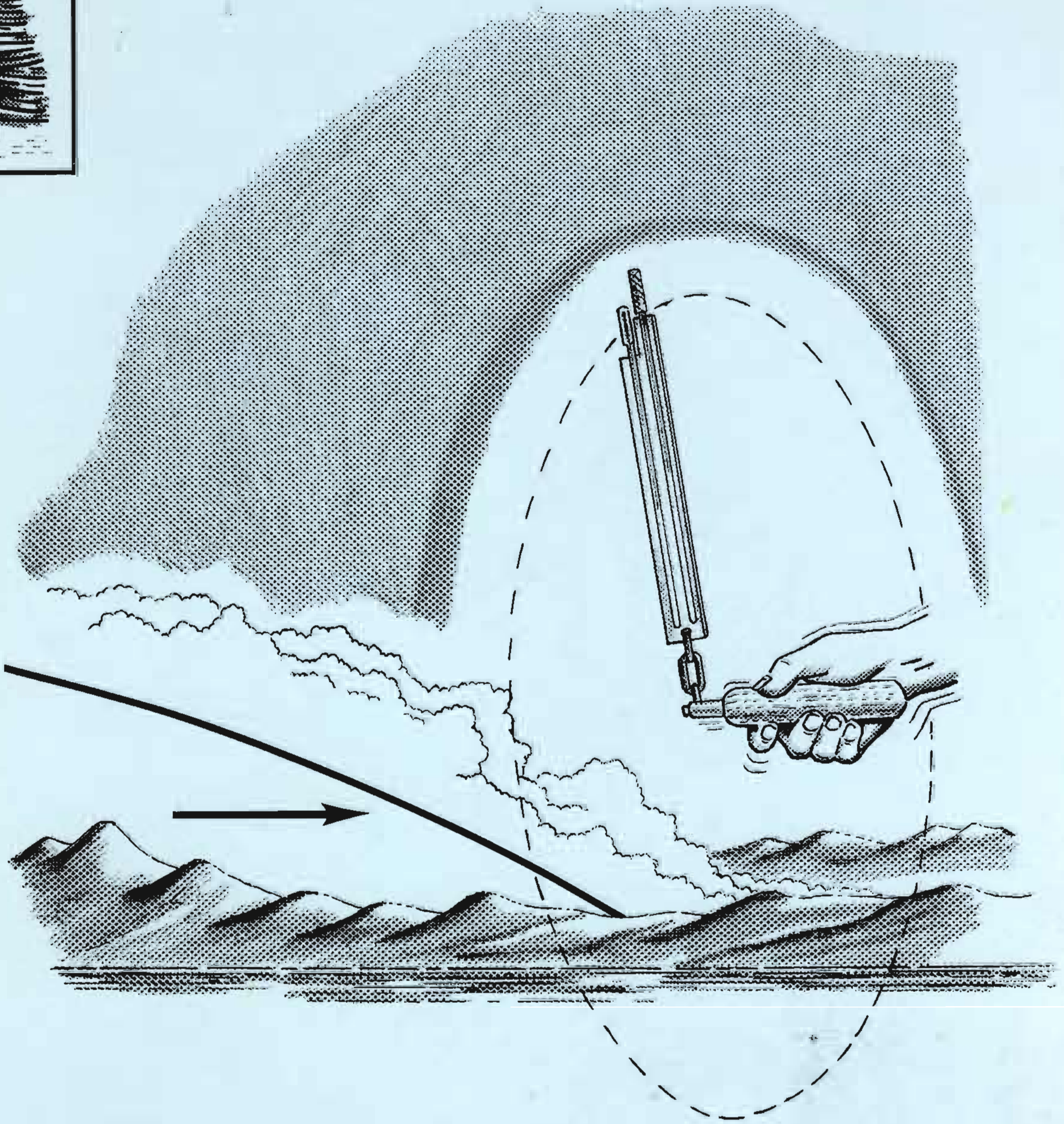
S [redacted]

This HUMIDITY business: what it is all about and its use in fire control

Clive M. Countryman



PACIFIC SOUTHWEST
Forest and Range
Experiment Station

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE
P.O. BOX 245, BERKELEY, CALIFORNIA 94701

1971

The Author

CLIVE M. COUNTRYMAN heads fire behavior studies at the Pacific Southwest Forest and Range Experiment Station, with headquarters at the Forest Fire Laboratory, Riverside, Calif. He earned a bachelor's degree in forestry at the University of Washington in 1940, and joined the Forest Service the following year.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price 25 cents
Stock Number 0101-0074

"HUMIDITY" is an eight-letter word that is heard around fire camps and on the fireline almost as often as the more widely known four-letter words. Most firefighters know that humidity has something to do with moisture in the air. If it is low, they expect difficulty in controlling the fire; if it is high, the fire can be expected to burn less aggressively—and perhaps may even go out by itself.

Humidity is a very general term, however. A weather specialist may use such confusing expressions as *absolute humidity, specific humidity, mixing ratio, vapor pressure, dewpoint,* and *relative humidity.* Each of these terms describes a different view of air moisture, and each has its value. But they all do not have the same importance in wildland fire control—relative humidity overshadows the rest.

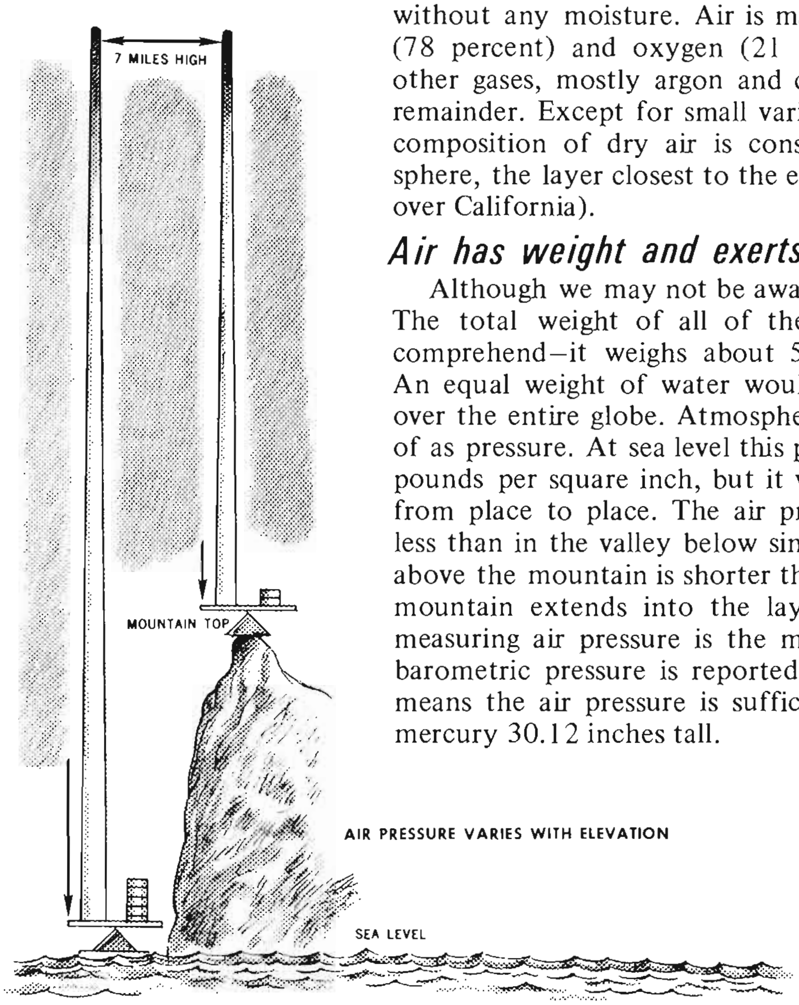
The following discussion is intended to sort out the meanings of different air moisture terms and show why relative humidity is so important.

AIR AND WATER

First, let us consider the characteristics of dry air—air without any moisture. Air is made up primarily of nitrogen (78 percent) and oxygen (21 percent). Small amounts of other gases, mostly argon and carbon dioxide, make up the remainder. Except for small variations in carbon dioxide, the composition of dry air is constant throughout the troposphere, the layer closest to the earth (up to about 7-1/2 miles over California).

Air has weight and exerts pressure

Although we may not be aware of it, air does have weight. The total weight of all of the atmosphere is difficult to comprehend—it weighs about 5,600,000,000,000,000 tons! An equal weight of water would form a layer 34 feet deep over the entire globe. Atmospheric weight is usually thought of as pressure. At sea level this pressure amounts to about 15 pounds per square inch, but it varies from time to time and from place to place. The air pressure on a mountain top is less than in the valley below since the vertical column of air above the mountain is shorter than that above the valley—the mountain extends into the layer of air. The standard for measuring air pressure is the mercury barometer. When the barometric pressure is reported as 30.12 inches, this simply means the air pressure is sufficient to balance a column of mercury 30.12 inches tall.

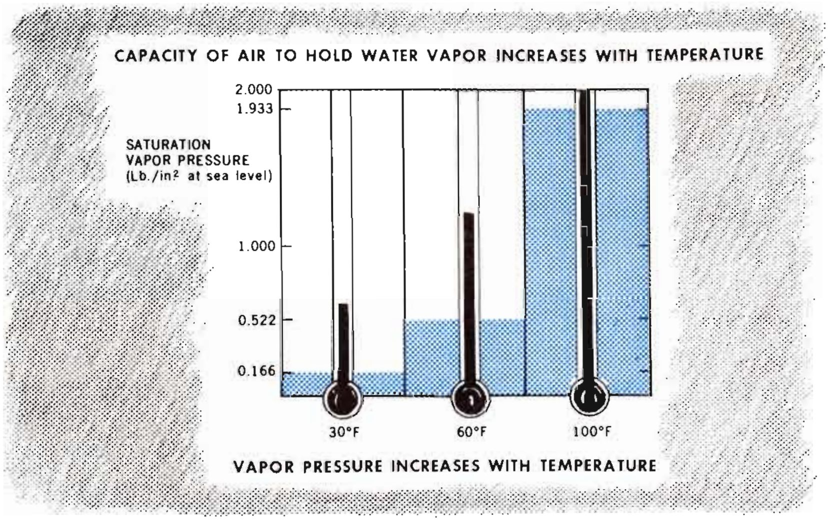


AIR PRESSURE VARIES WITH ELEVATION

Air tends to become saturated with water vapor

The moisture in air is, in reality, water vapor—another gas. The amount of water vapor in the air varies with both time and place, ranging from near zero to about 5 percent of the air volume. Water vapor gets into the air by evaporation from water and other moist surfaces and from transpiration by living vegetation. When mixed with air, water vapor acts as an independent gas—just as if water vapor is one gas and air another. Like air, water vapor has weight and, hence exerts pressure. The amount of pressure the water vapor exerts independent of the dry air pressure is called the *vapor pressure.* Water vapor is lighter than dry air, however, so contrary to our usual experience of things becoming heavier when they are moistened, moist air is lighter than dry air.

If we partially fill a container with water, put dry air on top, and then close the container, water vapor molecules will begin to leave the water surface and mix with the dry air above it. This process will be rapid at first and then slows until finally the number of water vapor molecules leaving the surface just balances the number returning. At this point, the air contains all of the water vapor it can hold–it is said to be *saturated.* The amount of pressure the water vapor exerts when the air is saturated is the *saturation vapor pressure.*



Temperature affects the saturation vapor pressure

If the temperature of the air is increased, it can hold more water vapor; and the saturation vapor pressure will be greater. At any temperature the saturation vapor pressure has a definite fixed value, but this value changes rapidly with temperature. At 30° F., the saturation vapor pressure is 0.166 inch, at 60° F., it is 0.522 inch, and at 100° F. it goes up to 1.933 inches of mercury.

The amount of water vapor needed to saturate a given *volume* of dry air depends on temperature only, and is not affected by pressure changes. But the amount of water vapor required to saturate a given *weight* of dry air does vary with pressure. For example, at sea level and with a temperature of 86° F., about 27.3 grams of water vapor are required to saturate 1,000 grams of dry air; 33.1 grams would be required at 5,000 feet elevation and the same temperature.

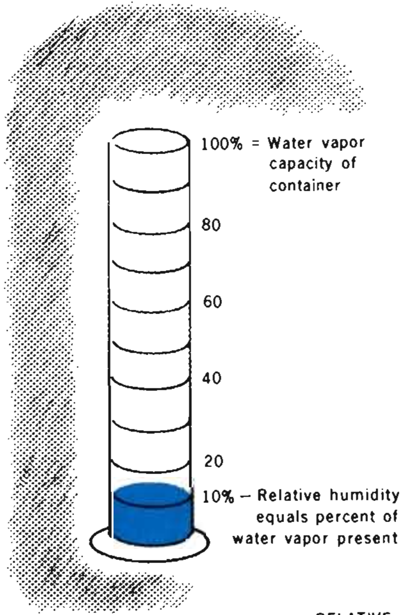
In the open, the air becomes saturated only under special conditions. Most of the time, particularly during the fire season, we are concerned with air that is not saturated–air containing less water vapor than it can hold. Thus, measures of the amount of water vapor that is actually present becomes of major importance in fire control.

Water vapor in air is measured in different ways

The actual amount of water vapor in the air can be expressed in various terms. The weight of water vapor per unit volume of air is called the *absolute humidity.* It is usually measured in grams per cubic meter. The actual weight of water vapor is small—a cubic meter of saturated air at 86°F. holds only 30.4 grams of water vapor. At less than saturation the weight is proportionately less. The weight of water vapor in a given weight of air (including the water vapor) is the *specific humidity.* It is usually expressed in grams per kilogram. Saturated air at 86°F. has about 26.6 grams of water vapor per kilogram of the mixture of air and water vapor.

The absolute humidity provides a measure of the weight of water vapor in a given *volume* of air. The specific humidity is a measure of the weight of the water vapor in a given *weight* of air and water vapor mixture. Still another measure of humidity is the *mixing ratio.* The mixing ratio is defined as the weight of water vapor per unit weight of dry air—the ratio of the weight of water vapor to the weight of the air without the water vapor. It differs from the specific humidity only in that the weight of dry air instead of the total weight of the mixture is used. Because the weight of water vapor is small, the mixing ratio is not much different than the specific humidity. At 86°F., the mixing ratio of saturated air is 27.3 grams per kilogram.

Relative humidity is the most helpful moisture measure in fire control



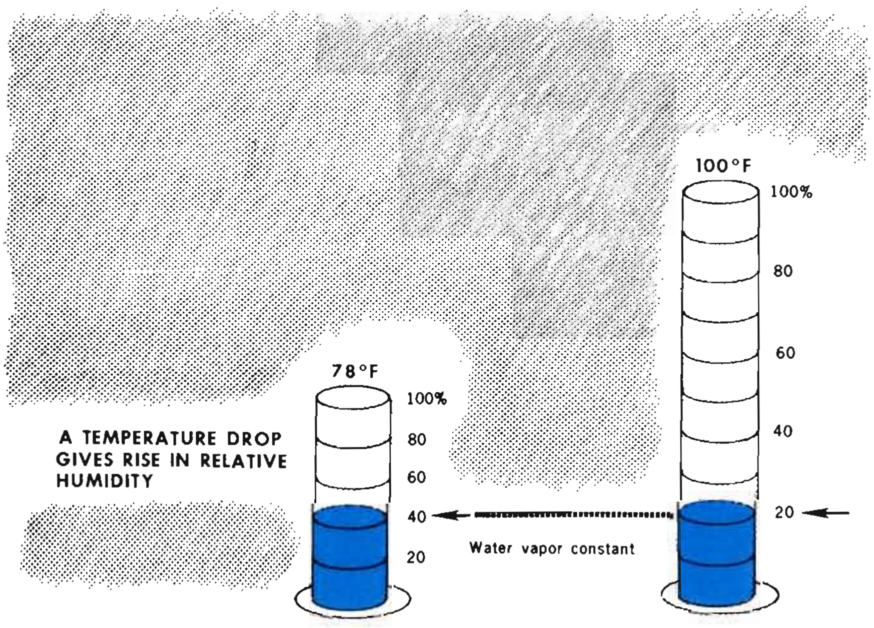
$$\frac{\text{ACTUAL MIXING RATIO}}{\text{SATURATION MIXING RATIO}} \times 100 = \text{RELATIVE HUMIDITY (\%)}$$

Absolute humidity, specific humidity, and the mixing ratio are measurements of air moisture used primarily in weather forecasting, special engineering applications, and in research. Hence, they are only of indirect interest in wildland fire control. But another measure of air moisture—*relative humidity*—is of major importance in wildland fire. Relative humidity is also the measure of air moisture we are concerned with for health and comfort. *Relative humidity* is a measure of the amount of water vapor actually in the air compared with the amount the air could hold if saturated. The relative humidity can be calculated from the mixing ratio, vapor pressure, or specific humidity. It has been agreed internationally that the mixing ratio will be used for relative humidity calculations. Thus, relative humidity can be technically defined as the ratio of the actual mixing ratio to the saturation mixing ratio at the same temperature. This ratio is usually expressed in percent.

For the moment, let us consider the air as a cylindrical glass container, 10 inches high, and with marks at 1-inch intervals on the container wall. Let us also consider the water vapor as a liquid rather than a gas. If we fill the container to the first mark with the liquid, one-tenth or 10 percent of the container's capacity will be occupied. If the container is filled to the second mark, it will be one-fifth or 20 percent full. As we continue to fill the container, a larger and larger proportion (percentage) of its capacity will be occupied by liquid—each mark on the container represents 10 percent of its capacity. When the liquid level reaches the top, the container will be filled to 100 percent of its capacity. So it is with air and water vapor. If the actual amount of water vapor in the air is only one-tenth of the amount it can hold, the relative humidity is 10 percent. When the air has all of the water vapor it can hold, it is saturated; and the relative humidity is 100 percent.

Relative humidity changes with temperature and pressure

Earlier it was pointed out that the amount of water vapor the air can hold depends largely on the air temperature—the lower the temperature, the less the capacity. This effect can also be illustrated by our glass container. Suppose we cut the container off at the 5-inch mark. The container will now have half its original capacity. And now each mark will indicate twice the proportion of the total capacity as it did before. Thus, if we fill the container to the first mark, it will be one-fifth or 20 percent full. The second mark will be 40 percent and so on. The same amount of liquid is added to reach each mark as when the container was full size, but since



A TEMPERATURE DROP GIVES RISE IN RELATIVE HUMIDITY the capacity of the container is only half the original, the proportion of the capacity occupied at each mark has doubled. In air we can achieve the same result by reducing the temperature. If air with 20 percent relative humidity is cooled until its saturation vapor pressure is cut in half, the relative humidity increases to 40 percent. Thus, the relative humidity moves in the opposite direction of the air temperature—increasing as the temperature goes down and decreasing as the temperature goes up.

This change of relative humidity with temperature occurs nearly every day. Early in the morning when the temperature is low, the relative humidity will be high, sometimes near 100 percent. But as the temperature rises during the day, the relative humidity drops—reaching a minimum at the same time the temperature reaches its peak. As the temperature decreases during the afternoon and evening, the relative humidity begins to climb again.

Because more water vapor is required to saturate a given weight of air as pressure decreases, we can also expect air pressure to affect relative humidity. Daily variations in air pressure do not have much effect on relative humidity and generally can be ignored. But changes in pressure with elevation are great enough to materially affect the relative humidity and must be considered in its measurement. For the same temperature and actual amount (weight) of water vapor, the relative humidity decreases as elevation increases. This change is reflected in the relative humidity tables for different elevations.

Under field conditions, however, the relative humidity near the ground may either increase or decrease as the elevation increases—chiefly for two reasons: First, air temperature usually decreases as elevation increases, and relative humidity depends greatly on temperature, as we have already seen. Even though the amount of water vapor in the air remains constant, the change in temperature with increase in elevation is usually large enough to offset the pressure effects, and the relative humidity will increase with elevation.

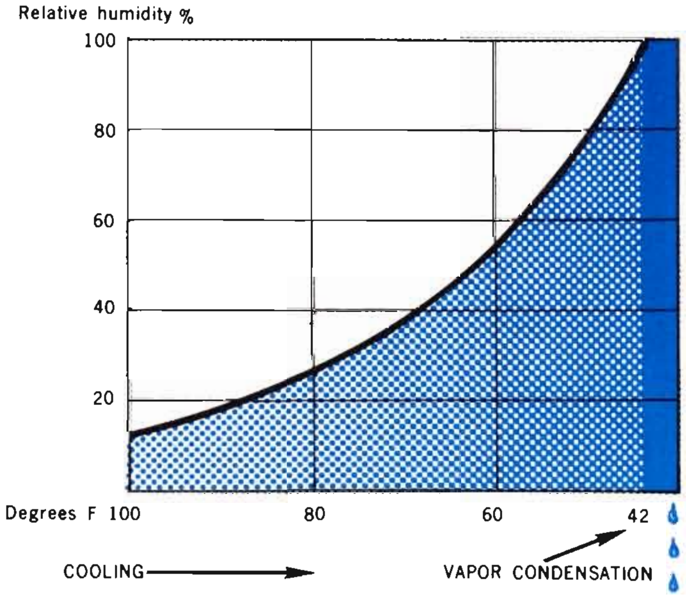
The second reason is that the amount of water vapor in the air is not likely to remain constant with increase in elevation, particularly if the change in elevation is large. The source of water vapor is the earth's surface. It reaches higher levels in the atmosphere by turbulent mixing and diffusion, and this process requires time. Usually air has a negative gradient of water vapor; that is, the amount of water vapor becomes less with increasing distance above the ground surface. Exposed ridges and hills may often be in air with less water vapor than land areas at lower elevations. And in such case the relative humidity will tend to decrease with elevation—temperature changes permitting. Thus, the way that the relative humidity actually changes with elevation will depend mostly on the relative importance of the water vapor and temperature gradients.

Dewpoint is a useful measure in fire control

A measure of air moisture that sometimes proves useful in fire control is the *dewpoint.* Suppose we have a parcel of air with a temperature of 100 degrees and a relative humidity of 14 percent. If the air is cooled to 80 degrees, the relative humidity rises to 26 percent. Cooling the air further to 60 degrees raises the relative humidity to 51 percent. If the cooling process is continued, the actual vapor pressure approaches the saturation vapor pressure until, at 42 degrees, they are the same, and the relative humidity is 100 percent. Any further cooling causes some of the water vapor to condense into visible water droplets. The temperature at which condensation first begins is the dewpoint.

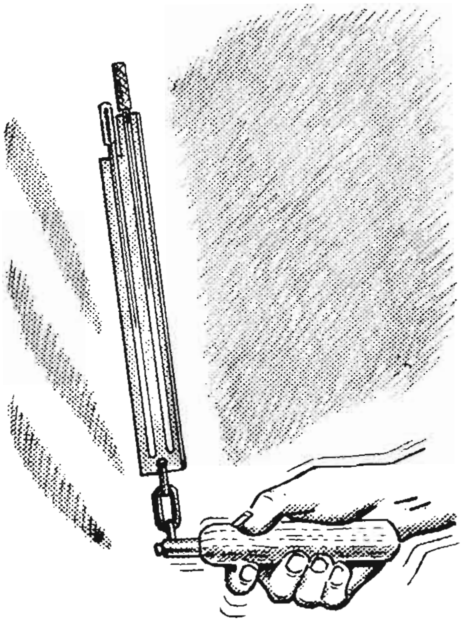
The formation of fair-weather cumulus clouds is a common example of air that is cooled to its dewpoint. The earth is heated unevenly by the sun, and the air over the hotter areas becomes warmer and lighter than the air adjacent to it. The warm air then rises in the form of bubbles. But as an air bubble rises, it cools by expansion. If the air that was near the ground has enough moisture and is cooled below its dewpoint, condensed water droplets will appear in the form of a cloud. If enough condensation takes place, the water droplets merge into larger drops, and a rain shower results.

The dew that forms at night is another example of air cooled below its dewpoint. In this case, the air that comes in contact with a cold surface is chilled below its dewpoint, and the condensed water is deposited on the surface. Materials that cool rapidly at night, such as metal and glass, are the first to receive a dew deposit. This condition explains why a car parked outside at night may be covered with dew when there is no sign of dew on the ground surface.

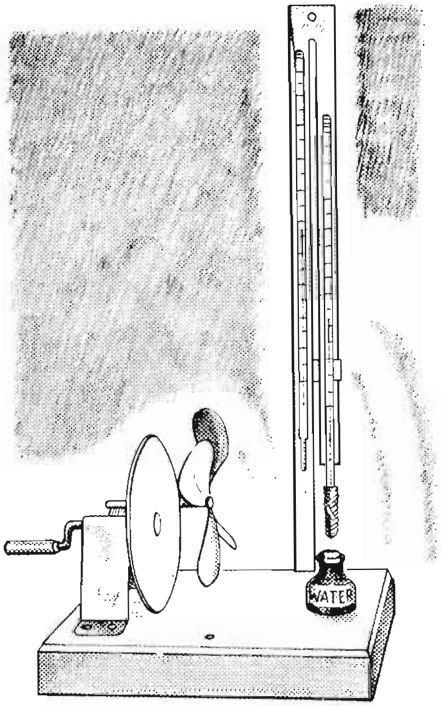


MEASURING RELATIVE HUMIDITY

The psychrometer is used with tables of relative humidity



SLING PSYCHROMETER



FAN PSYCHROMETER

Numerous instruments and methods have been devised to measure air moisture, but, in wildland fire control activities, only two types of instruments are in general use. One is the *psychrometer.* It consists of two mercury thermometers fastened in some kind of rack or stand. One of the thermometers has its bulb covered with a muslin wick—this is called the wet-bulb thermometer. The other thermometer—the dry-bulb thermometer—is left bare. In use, the wicking is moistened with water and a stream of air is directed across both thermometer bulbs with a fan or by swinging the thermometers through the air with a short cord or chain. This latter type is called a *sling psychrometer,* and is widely used in the field since it is easily carried. When the thermometers are ventilated, the moisture in the wick evaporates, cooling the wet-bulb thermometer, which thus shows a lower temperature than the dry-bulb thermometer.

The amount the wet bulb thermometer is cooled depends directly on the relative humidity of the air. From the wet-bulb and dry-bulb temperatures, the relative humidity can be read from a set of psychrometric tables. In one type of table, the wet-bulb and dry-bulb temperatures are used directly. The National Weather Service publishes tables of this type. The relative humidity is read at the intersection of the wet- and dry-bulb temperature columns. In this table, the lower number at the intersection is the relative humidity while the upper number is the dewpoint. Another type of table uses the dry-bulb temperature and the difference in temperature between wet- and dry-bulb readings—*the wet bulb depression*—instead of the wet bulb temperature. Since relative humidity varies with elevation, tables have been compiled for several ranges of elevations.

WET BULB TEMPERATURES

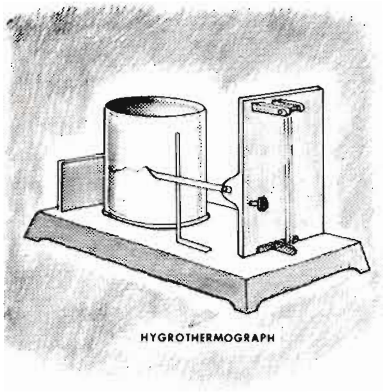
DRY BULB TEMPERATURES	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
70	-14 3	0 6	+9 9	16 12	21 16	26 19	30 22	33 26	36 29	39 33	42 36	45 40	47 44	49 48	51 51	53 55
71	-26 2	-5 5	+5 8	13 11	19 14	24 17	28 20	32 23	35 27	38 30	41 34	44 37	46 41	48 45	51 48	53 52
72		-13 3	+1 6	10 9	16 12	22 15	26 18	30 21	34 24	37 29	40 31	43 35	45 38	47 42	50 45	52 49
73		-26 2	-5 4	+6 7	13 10	19 13	24 16	29 19	32 22	36 25	39 29	41 32	44 35	47 39	49 42	51 46
74			-13 3	+1 6	10 8	17 11	22 14	29 17	31 20	34 23	37 26	40 30	43 33	46 36	48 40	50 43
75			-25 2	-4 4	+6 7	14 10	20 12	25 15	29 18	33 21	36 24	39 27	42 31	45 34	47 37	49 40
76			-57	-12 3	+2 5	11 ·8	17 11	23 14	27 16	31 19	35 22	38 25	41 28	44 31	46 35	49 38
77				-23 2	-3 4	+7 7	15 9	21 12	25 15	30 18	38 20	37 23	40 26	43 29	45 32	48 35

Pressure 30"

Elevation 0-500

The hygrograph records changes in relative humidity

The second type of instrument used to record air moisture provides a direct measure of relative humidity and records it on a chart. This is the *hair hygrograph.* In this instrument, several strands of human hair—blonde preferred—with the oil removed are anchored at one end and connected through a system of cams and levers to a movable pen at the other. The pen rests on a rotating, chart-covered, drum driven by clockwork. As the relative humidity varies, the hairs change in length, becoming longer as the humidity increases and shorter as it decreases. This change in length is recorded on the chart by the pen, giving a continuous record of the relative humidity. The chart is calibrated so that the humidity can be read directly. Some types of instruments also have a bimetallic temperature sensing unit that changes in shape as the temperature changes. This movement is recorded by another pen on the clock-driven drum, thus providing a temperature record. When both temperature and humidity are recorded, the instrument is called a *hygrothermograph.*



HUMIDITY AND FUEL MOISTURE

Fuel moisture content depends on relative humidity

Surprisingly, water vapor has little direct effect on fire. Under some special conditions, water vapor can promote smoother combustion. But these conditions are usually limited to a confined fire, such as in furnaces and internal combustion engines; thus, a car may seem to run better on a rainy or foggy day. For wildland fires, the direct effect of water vapor is negligible.

Why then the concern about humidity in wildland fire control and fire behavior? Because humidity affects the moisture content of dead wildland fuels. In dry fuels, fires start easily and spread rapidly. But, when the moisture content of fuels is high, they are difficult to ignite and fires spread slowly, if at all. In the absence of rain or other forms of liquid water, the amount of moisture in dead fuels is controlled to a large degree by the humidity of the air.

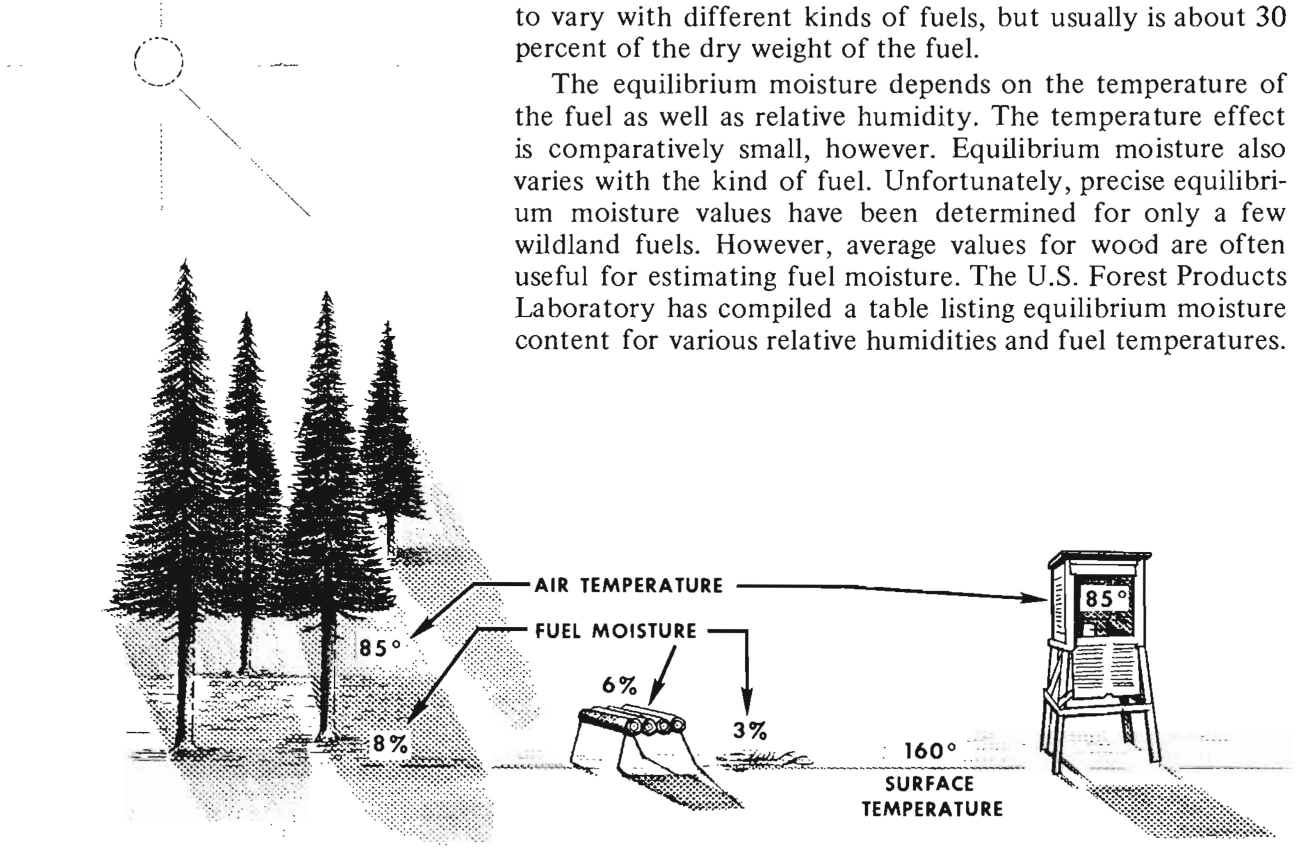
Dead fuels are hygroscopic; that is, they can take water vapor from the air or add water vapor to it. The amount of moisture fuels can adsorb and hold from the air depends primarily on the *relative humidity* of the air—not on the actual amount of water vapor as indicated by the specific humidity, absolute humidity, or the mixing ratio. Thus, in wildland fire applications, we need to be more concerned with relative humidity than with the other terms used to indicate atmospheric moisture.

Fuels tend to reach equilibrium moisture content

If a piece of very dry fuel is exposed to air with a moderate relative humidity, say 30 percent, the fuel increases in moisture content. The increase will be rapid at first, then slows, and finally stops. Exposing the fuel for a longer time does not further increase the moisture content. The moisture content of the fuel is then in equilibrium with the relative humidity, and the actual moisture content of the fuel is its *equilibrium moisture content.* Increasing the relative humidity of the air results in an increase in the moisture content of the fuel until it is again in equilibrium with the new relative humidity. For every level of relative humidity, there is a corresponding equilibrium fuel moisture content. Thus, fuel moisture can be expected to change in·accordance with the relative humidity.

When exposed to saturated air (100 percent relative humidity) the fuel reaches the highest moisture content possible from adsorption of water vapor from the air. The moisture content at this point is the *fiber saturation moisture content* of the fuel. Further increase in the moisture content of the fuel requires the addition of liquid water in the form of rain, dew, or snow. The fiber saturation moisture is known to vary with different kinds of fuels, but usually is about 30 percent of the dry weight of the fuel.

The equilibrium moisture depends on the temperature of the fuel as well as relative humidity. The temperature effect is comparatively small, however. Equilibrium moisture also varies with the kind of fuel. Unfortunately, precise equilibrium moisture values have been determined for only a few wildland fuels. However, average values for wood are often useful for estimating fuel moisture. The U.S. Forest Products Laboratory has compiled a table listing equilibrium moisture content for various relative humidities and fuel temperatures.



Fuel moisture must be estimated with caution

From a table, it would seem to be a simple matter to obtain fuel moisture of wildland fuels from relative humidity and temperature measurements recorded at a fire weather station, fire camp, or on the fireline. Unfortunately, the problem is not this simple, and equilibrium moisture values must be used with caution. There are two main reasons for this.

First, the moisture content of the fuel is controlled by the relative humidity and temperature of the air immediately surrounding the fuel. Earlier, we pointed out that relative humidity depends largely on air temperature. And air temperature can vary greatly in time and horizontal and vertical space. Thus, relative humidity and air temperature measurements as usually made in an instrument shelter or with a sling psychrometer may or may not represent the conditions surrounding the fuel of interest. For example, on clear days with light winds, the ground surface and the fuels on it become quite hot. It is not unusual for surface temperatures to reach 160° to 165° F. when the air temperature measured in a standard instrument shelter nearby is only 80° to 90° F. Close to the hot ground surface, the air also becomes warm and the relative humidity considerably less than that of air only a short distance above the ground. In open areas during the summer, the moisture content of small surface fuels may be only about one-half that of fuels exposed a foot above the surface. At night the situation can be reversed. The ground surface becomes cold first and cools the air close to it, raising its relative humidity. This condition in turn increases the fuel moisture so that the surface fuels at night may have a higher moisture content than fuels above the surface. Thus, any condition that results in an air temperature near the fuel that is different from measured temperature also results in a different relative humidity and fuel moisture. Thus, in deep canyons, as compared with exposed slopes, or timbered areas, as compared with open areas, significant temperature and relative humidity differences can be expected to exist.

Temp. °F.	Relative humidity %		
	20	30	40
	Equilibrium moisture content (percent)		
40	4.6	6.3	7.9
45	4.6	6.3	7.9
50	4.6	6.3	7.8
55	4.6	6.2	7.8
60	4.6	6.2	7.7
65	4.5	6.1	7.7
70	4.5	6.1	7.6
75	4.5	6.0	7.5
80	4.4	5.9	7.4
85	4.4	5.9	7.3
90	4.3	5.8	7.2
95	4.3	5.7	7.1
100	4.2	5.6	7.0
103	4.1	5.5	6.9
110	4.0	5.4	6.8
115	3.9	5.3	6.7
120	3.8	5.2	6.5

The second need for caution in using equilibrium moisture values arises from the time required for the fuel to adsorb from the air, or lose moisture to it. Fine fuels with a large surface area compared to their volume, such as grass, leaves, and small twigs, can reach their equilibrium moisture content in a few minutes, but large limbs and logs take a long time. Limbwood 2 inches in diameter may require up to 4 days at a constant relative humidity and temperature to reach equilibrium; for logs, weeks or even months may be needed. Since relative humidity is usually continuously changing, the actual fuel moisture lags behind the equilibrium moisture. The amount of this lag depends on how fast the relative humidity is changing, the size of the fuel, and how well the air can circulate around the fuel—loosely arranged, well aerated fuels will have moisture contents nearer equilibrium values than more compact fuel beds.

Despite these drawbacks, equilibrium moisture content provides a useful tool in fire control, fire use, and the prediction of fire behavior. Fine fuels, surfaces of larger fuels, and the top layer of litter and duff are usually close to their equilibrium moisture. These are the fuels that have the greatest effect on the ease of ignition, rate of fire spread, and probability of fire spotting. So, if relative humidity is measured in the vicinity of the fuels and allowance made for the probable fuel temperature, good estimates of actual fine fuel moisture can be made from the equilibrium moisture content. For the larger fuels, estimates of actual fuel moisture from equilibrium moisture are not reliable. The trends in the moisture content of these fuels can, however, be deduced from successive relative humidity measurements and equilibrium moisture determination.

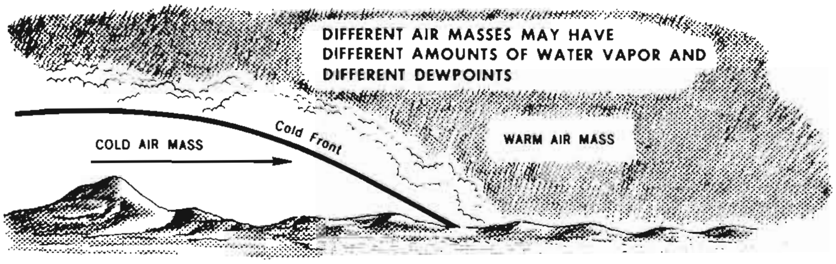
DEWPOINT AND FIRE CONTROL

Dewpoint is an indicator of weather changes

Relative humidity has been used in fire control operations and in fire behavior prediction for a long time, but the value of another air moisture indicator—the dewpoint—has generally been overlooked. The actual amount of water vapor in the air as indicated by its specific humidity, absolute humidity, or mixing ratio is not constant. It varies from time to time and from place to place. Different air masses usually hold different amounts of water vapor, so the movement of air masses with changes in the weather usually brings changes in the water vapor content of the air. Within a given air mass there are also variations in the amount of water vapor. Air near good sources of water vapor—lakes, streams, moist ground, and growing vegetation—generally hold more moisture than that over dry areas. Dewpoint does not provide a direct measure of the moisture in the air, but it does give a comparative one—the higher the dewpoint, the more moisture the air contains.

How can the dewpoint be used in fireline operations? One use is to detect the onset of a weather change. The arrival of a new air mass at the fire area is often of critical importance since it may mean a drastic change in wind speed or direction or in the relative humidity. Fire weather forecasts can provide warning of such a change, but the time this change will take place at a particular point is often difficult to predict with accuracy. Small fluctuations in the dewpoint are common in any air mass; but a consistent trend, either upward or downward, is a good indicator of the arrival of a new air mass. Weather changes seldom take place abruptly.

Dewpoint observations made from time to time in the area of interest can reveal the beginning of a change before it is otherwise apparent. This technique works with small-scale weather changes as well as large. In coastal areas, for example, the arrival of the sea breeze can be detected from an increase in the dewpoint.



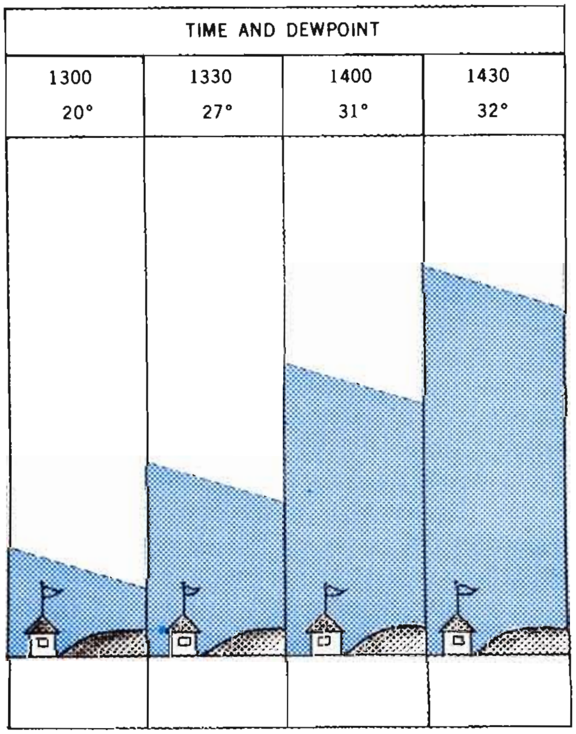
Dewpoint is a valuable indicator of local moisture conditions

The dewpoint can also be used to localize a fire weather forecast. Suppose a division boss on a large fire has the responsibility for constructing and burning out a fireline down a spur ridge and along a canyon bottom. The fireline ranges from 2,500 to 4,000 feet elevation. The plan is to construct the line during the day and to fire it out at night when cooler temperatures and higher humidity will lessen the change of fire escape during the burning-out operation. The winds are light, varying from 6 to 10 miles per hour. Throughout the day the division boss has been recording temperature and humidity with a sling psychrometer on both the ridge and canyon bottom line locations. He has noted that the canyon bottom air has been somewhat cooler and the humidity higher than on the ridge. He attributes these differences to the taller vegetation and small amounts of water in the nearly dry stream bed of the canyon.

By midafternoon the temperature on the ridge is 90° F. and the relative humidity 15 percent—about what the fire weather forecast indicated for the fire area. But at about the same time, the temperature in the canyon bottom was 84° and the humidity 25 percent. The division boss receives a night fire weather forecast which predicts that by 0200 hours the temperature will drop to 60° to 65° and the humidity will rise to 35 to 40 percent. Wind will be slight. These conditions will not interfere with burning out the ridge line, but the division boss is concerned about the canyon bottom line. Consulting his tables on relative humidity and dewpoint, the division boss finds that a relative humidity of 15 percent and a temperature of 90° indicate the dewpoint is 37°, while a temperature of 84° and a humidity of 25 percent give a dewpoint of 45°. The night temperature and relative humidity forecasted also give a dewpoint of 37°, indicating the fire weather forecaster does not expect a change in the air mass. If the temperature in the canyon bottom drops to the forecast of 60°, the division boss finds from his tables that the relative humidity will be between 48 and 55 percent because of the higher dewpoint in this location. At this humidity, the burning conditions are likely to be marginal. But the division boss also knows that because of cold air drainage into the canyon, the temperature there is likely to be considerably colder—probably as much as 10°. If the temperature drops to 50° or 55°, the relative humidity will range from 69 to 84 percent—too high for successful burning. The division boss then decides he must complete the burning operation early in the evening if it is to be successful. He then arranges for enough crews to complete the job within the time limits.

Thus, with only a sling psychrometer and a set of relative humidity and dewpoint tables, the fire weather forecast can be localized to fit a specific fireline situation.

CONSISTENT TREND IN DEWPOINT CAN INDICATE CHANGE IN AIR MASS



SUMMARY

For fire control purposes, we can think of the atmosphere as being composed of two gases—air and water vapor. Each of the various ways to measure the amount of water vapor in the air has its own use. For wildland fire, we are principally concerned with the relative humidity, because it affects the moisture content of the wildland fuels. Both air and fuel, like sponges, are limited in their capacity to take up moisture. The capacity of air is controlled by temperature and pressure. However, air is seldom filled to its capacity with water vapor; relative humidity simply indicates the amount of moisture the air actually has compared with what it could hold.

The amount of moisture dead wildland fuels can adsorb is fixed for every level of relative humidity and fuel temperature. The fuels are continuously striving to attain this equilibrium value, but wildland fuels are slow-acting sponges. Because relative humidity and fuel temperature are usually continuously changing, the actual moisture content of the fuels lags behind their equilibrium moisture content. For individual fuel particles the amount of lag depends mostly on the fuel dimensions—the larger the surface area in relation to the fuel volume, the less lag there will be. Thus, fine fuels are usually close to their equilibrium moisture content, but the moisture content of large fuels may deviate considerably. The compactness of the fuel bed also affects the lag of actual fuel moisture behind the equilibrium value. Loosely arranged, well-aerated fuel beds will have moisture contents nearer equilibrium than more compact fuel beds.

The equipment needed to measure relative humidity in the field is simple and inexpensive—all that is needed is a sling psychrometer and a set of humidity tables. Understanding of its relation to fuel moisture makes relative humidity a convenient and useful tool in wildland fire control activities.

☆ GPO 790-483

The Forest Service of the U.S. Department of Agriculture

... Conducts forest and range research at more than 75 locations from Puerto Rico to Alaska and Hawaii.

... Participates with all State forestry agencies in cooperative programs to protect and improve the Nation's 395 million acres of State, local, and private forest lands.

... Manages and protects the 187-million-acre National Forest System for sustained yield of its many products and services.

The Pacific Southwest Forest and Range Experiment Station

represents the research branch of the Forest Service in California and Hawaii.