A RELATIONSHIP OF METEOROLOGY TO FOREST FIRE PROTECTION & Meteorology

by

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INTRODUCTION

The systematic study of the influence of weather upon forest fires is of comparatively recent origin. Forestry itself was inherited from European sources and for the most part considerable volume of literature on silviculture, wood technology, forest pathology and forest entomology is available. There is no comparable literature on the subject of forest fires of "forest pyrology" to use an expressive term coined by Gisborne.[3]

The development of meteorology and weather lore has always been dependent on the weather in its relation to the security and comfort of a people. In places where the weather was seldom rigorous, little was done towards development of the science of weather. On the other hand, where weather was depended on for continued security or prosperity, the science of weather? became developed.

This also holds true for the interest in forest fires. In Europe the lack of interest on the subject of forest fires is understandable when a normal summer season is investigated. The summers in Europe have a comparatively more plentiful and frequent rainfall, so that there are relatively fewer days on which fires can spread. In regions of normally ample summer rainfall, serious forest fire losses are confined to abnormal years. In many regions of the North American continent, the normal summer rainfall is insufficient to prevent forest fires, and it is only in abnormal years that there are small fire losses. Therefore it is necessary in fire control planning in this region to take an interest in the weather.

Fire control planning must aim at developing a plan with enough flexibility to enable the manager to meet present or probable changes in the conditions which cause fire to burn at any given degree of intensity. These conditions are primarily weather, and are divided into short and long time changes.

Up until recently, fire danger has dealt only with what has occurred, but it is recognized that action as far as possible should be aimed at preparing to meet danger before it occurs. The forecasting of the weather conditions which will affect tomorrow's fire danger has become increasingly important. The United States Weather Bureau has provided fire weather forecasts for a number of years. It is an art which has improved and still has room for improvement, but considerable action can be taken on the basis of these forecasts.

A RELATIONSHIP OF METEOROLOGY TO

FOREST FIRE PROTECTION

SHORT TIME CHANGES

The primary conditions which are variable and change in short times are:

1. Fuel moisture and inflammability of fuels.

2. Weather factors.

FUEL MOISTURE AND INFLAMMABILITY OF FUELS

For forest fuels to burn there must be a sufficient quantity of fuel physically arranged in a manner conducive to combustion, and the moisture content of the fuel must be low enough to permit combustion. Also there must be an ignition agent capable of supplying enough heat to ignite the fuel.

Usually forest fuels are so arranged that they are already conducive to burning. So it is the moisture content of the fuels which is the variable which determines whether or not a fuel will burn. This variability is largely dependent on weather factors, and is measured by the weighing of fuel sticks. Generally, fuel moisture follows the trend of relative humidities except that there is an equilibrium time lag of about two hours. On an average the relative humidities reached their minimums around three P. M. while the fuels continued to lower in fuel moisture content until five P. M. Relative humidities in the mornings are at a maximum at approximately four A. M. and the maximum fuel moisture content occurs at approximately six A. M.

In following through with the above averages it is readily seen that the lighter the fuels the more the daily fluctuation, and the more quickly the fuels tended to equal the average daily relative humidity.

At the Priest River Experiment Station in Idaho, Gisborne defined the inflammability of western white pine duff into the following zones.[8]

Inflammability	Duff Moisture Content in Per Cent	Ignition Agent Effective
None	Over 25	None
Very low	19 - 25	Large slash fires
Low	14 - 18	Camp fires
Medium	11 - 13	?
High	8 - 10	Dropped matches
Extreme	0 - 7	?

In the Adirondacks for eastern mixed wood forests the inflammability based on moisture content of the duff is shown in the following table.[8]

Inflammability	Duff Moisture Content in Per Cent	Ignition Agent Effective
Generally safe	30 or more	None
Very low	23 - 29	Camp fires
Low	17 - 22	Matches
Medium	11 - 16	Pipe heels
High	6 - 10	Locomotive sparks
Extreme	0 - 5	Cigarettes

The above tables are of value in fire control and with little revision could be made to fit any section of the country.

WEATHER FACTORS

The weather factors of interest in this report are those that influence fuel moistures. There are a number of physical properties and conditions of the atmosphere that may be observed and measured, and which it is necessary to observe and measure if a correlation is desired between weather and forest fire danger.

RAINFALL: Rainfall is of prime importance as it is the principal source of moisture in fuels.

The annual precipitation is not of so much importance as the monthly rainfall. It was found in Eastern Montana with some fourteen plus inches of annual rainfall and an average of three inches during the summer months that only a fraction of the losses sustained by Idaho occurred. Idaho had an annual rainfall of some thirty plus inches, but only one and four tenths inches per month occurred during the summer months of July and August.[8]

Further analysis shows that a minimum of two inches per month during the summer fire season is needed to prevent development of serious fires. Also the winter precipitation has little effect upon fires the following summer fire season.

With a minimum of two inches of precipitation needed to prevent serious fires, a graph can be readily constructed for any area where average monthly precipitation records have been kept. Plot average precipitation per month against the month of the year. Normal lengths of the fire season will be shown by noting what months fall below the minimum precipitation limit of two inches. Also the most critical part of the anticipated fire season may be crudely estimated by noting the months with the lowest amounts of precipitation.

It was also found that rains of six tenths inch or more over a period of forty-eight hours are needed to saturate the average forest duff. Also, that two tenths inch of rain in twenty-four hours would prevent fires from spreading temporarily or for approximately twenty-four hours.

Except in very light showers the loss of rain reaching the ground because of foliage is about forty per cent, but this is more than compensated for by the slower drying rate under the foliage.[4]

<u>TEMPERATURE</u>: A weather element of primary concern is temperature, meaning the temperature of the air.

Temperature has its greatest influence on the capacity of the air to hold moisture. For example, at one hundred per cent relative humidity, one cubic foot of air at sixty degrees Fahrenheit will hold only one third as much water vapour as one cubic foot of air at ninety degrees Fahrenheit. Another example would be a sample of air at sixty degrees Fahrenheit and fifty per cent relative humidity. If heated to ninety degrees Fahrenheit, the relative humidity will be decreased to nineteen per cent.[9]

Another effect of temperature changes is the rate of evaporation. The rate of evaporation is roughly proportional to the difference between the wet and dry bulb readings of a psychrometer. At sixty degrees Fahrenheit and fifty per cent relative humidity, the depression is ten degrees Fahrenheit. At ninety degrees Fahrenheit and nineteen per cent relative humidity, the depression in twenty-seven degrees Fahrenheit or the rate of transfer of moisture from wet fuels to air is nearly three times as fast in the latter case as compared to the former case.

Even with the above effects of temperature on fire dangers true, the correlation between fires and temperatures has not proved to be a good individual measuring stick. ~~Although~~ From general observations, serious fires are generally not associated with temperatures below fifty degrees Fahrenheit.

The following table is set up using temperature and inflammability of forest fuels, but should be used in conjunction with known duff moisture contents, rate of drying and wind velocities.[8]

Temperature	Inflammability of Fuels
55° F. or less	Generally considered safe.
56° - 70° F.	Slightly dangerous.
71° - 85° F.	Dangerous
Over 85° F.	Extremely dangerous.

Peak temperatures during the day under the forest canopies were averaged at about three P. M., but in the open areas the peak temperatures persisted and averaged another two hours longer. The peak was also reached earlier in the day on open areas.[4]

<u>RELATIVE HUMIDITY</u>: Some of the moving molecules at the surface of a liquid are continually escaping and entering the air as gaseous molecules. Raising the temperature increases the velocity of the molecules and the rate at which they break free from the liquid surface. It is thus that gaseous water, commonly called water vapor, enters the air from water surfaces and from soils and plants. This process is called evaporation.

In dealing with the moisture in the air, a measurement called relative humidity is used. This may be defined as the ratio of the actual quantity of water vapor in a given volume of air to the possible quantity in the same space at the same temperature. Relative humidity is a ratio between two masses or two pressures, and therefore may be expressed as a percentage.[2]

Strong winds, steep slopes and intense heat from burning materials cause an increase in the rate of spread only after the materials have reached a certain degree of inflammability. Regardless of the above factors a fire will be slowed up and maybe even stopped if the relative humidity of the air becomes high.

In general the behavior of fires were drawn up and the following conclusions arrived at.[8]

Relative Humidity in %	Fire Behavior
Above 60	No spread.
50 - 60	Slow spread in favorable fuels.
40 - 50	Spread begins to pick up.
30 - 40	Gains headway and may spread rapidly.
Below 30	May get out of control.
Below 25	Good chance of a crown fire.

Efforts have been made to separate statistically the effects of wind velocity and relative humidity upon fires. The general conclusion is that relative humidity alone should not be used as an index to fire behavior.

To use the following scale[8] that interprets relative humidity in per cent in terms of inflammability, it is necessary to know the kind of fuel, its present moisture content, its exposure, the rate of evaporation, the temperature and wind velocity. In considering the kind of fuel it should be understood that smaller fuels have less time lag in absorbing moisture than larger fuels. The time lag for the common duff fuels is about two hours.[4]

Relative Humidity in %	Inflammability
Over 70	Generally safe.
46 - 70	Slightly dangerous.
26 - 45	Dangerous.
25 and under	Extremely dangerous.

WIND AND CURRENTS: Wind is air which is in approximately horizontal motion. Vertical movements in the air are commonly called currents. Winds are of fundamental importance in making our weather what it is. In the first place, the motion itself is a weather factor of importance. In the second place, the physical condition of the air is largely a function of its source and its movement. This last statement is well illustrated on the west side of the Cascade range. Winds from the southwest are moist and apt to mean rain or cloudy weather, while winds from the east are dry and apt to mean hot clear weather.

The following chart is an attempt to correlate occular estimates, actual miles per hour and the terms used in Weather Bureau forecasts.[2]

Specifications for use on land.	Miles per hour.	Terms used in forecasts
Smoke rises vertically.	Less than 1.	Light
Direction of wind shown by smoke drift, not on vanes.	1 - 3	Light
Wind felt on face; leaves rustle; vane moved.	4 - 7	Light
Leaves and small twigs in constant motion; blows light flag.	8 - 12	Gentle
Raises dust and loose paper; small branches are moved.	13 - 18	Moderate
Small trees in leaf begin to sway.	19 - 24	Fresh
Large branches in motion; whistling heard in telegraph wires.	25 - 31	Strong
Whole trees in motion; inconvenience felt in walking against wind.	32 - 38	Strong
Breaks twigs off trees; generally impedes progress.	39 - 46	Gale
Slight structural damage occurs, shingles removed.	47 - 54	Gale

Trees uprooted; considerable damage occurs	55 - 63	Whole gale
Rarely experienced; widespread damage occurs.	64 - 75	Whole gale
	Above 75	Hurricane

Before a fire has started, a detriment of the wind is that it accelerates the rate of drying by carrying away the layers of air in contact with the fuels as they become saturated. Once a fire is going, the main influence of the wind is on the rate of spread. The fire spreads by the winds feeding the flames by fanning and driving the heat against adjacent fuels. Also burning embers are spread in advance of the fire by the wind and currents produced by the heat of the fire. Because of these factors it is of prime importance to have information on wind direction and velocity to plan adequate fire control action. It should be understood that the primary winds of an area may be greatly effected by secondary winds. Such effects include land and sea breezes, mountain and valley circulations, and funneling effects of canyons or a series of ridges.[1]

In a study of large fires it was found that rate of spread was influenced chiefly by wind and wind direction. It was also found that on the average, fire advances three to four times as fast with the wind as against it. On the average the rate of lineal advance of fire with the wind varies with the square of the wind's velocity.[8]

An important factor to be taken into consideration is to know at what height or level wind measurements that might be received are taken. It was found that a wind of fifteen miles per hour at a hundred and fifty-six foot level produces a velocity of only one and a half miles per hour at two feet above the forest floor. Winds of over thirty miles per hour seldom raised the wind at two feet above the forest floor over three and a half miles per hour.[4] This has an important effect on small fires in forested areas, but on large fires that have opened up the area the relationship would be changed.

INSOLATION AND SOLAR RADIATION: Radiation refers both to the radial emission of energy from an object and to the energy so transferred. The energy is said to be transferred in waves. The waves received from the sun and those sent out by the earth are those with which we are particularly concerned in this report. That portion of the radiant energy which enters a substance but is not transmitted through it is said to be absorbed. It hereby ceases to be radiant energy and is changed into some other form of energy, often into heat, but sometimes into the energy used in evaporation or in chemical changes.

The heat of the atmosphere and of the surface of the earth is derived almost wholly from the sun. This incoming solar radiation, which is of primary importance to meteorology, is given the special name of insolation. Although the earth receives but a minute portion of the total radiation emitted by the sun, owing to the small angle subtended by the earth as seen from the sun, the amount received is great. The important factors governing insolation are: duration of sunshine, angle of incidence, and absorption and reflection by the air. The total radiation arriving at any point on the earth's surface in any twenty-four hour period depends on the latitude, the time of year, and the clearness of the atmosphere.[2]

Of the radiation which gets through the atmosphere and reaches the surface of the earth, a part is reflected back into the atmosphere, and the remainder is absorbed at the surface. The proportion that is reflected by land surfaces varies greatly with the condition and color of the surface. If the land is covered with grass or trees, or is black, cultivated soil, the reflection may be approximately ten per cent. A bare, hard, sandy soil may reflect twenty per cent, and freshly fallen snow seventy per cent of the radiation.[4] Heat does not penetrate deeply into the soil but remains in a thin surface layer, the daily variation being small below four inches.[2] For this reason the surface heats rapidly, but a good absorber is a good radiator, and the land surface that warms rapidly by day cools rapidly by night. Moist soil does not heat so rapidly as dry soil because some of the energy received is used in evaporating the water, and because it takes more energy to heat water than soil.

From the foregoing it can be seen that the exposure of fuels to the sun greatly hastens the rate of drying. The rate of evaporation is also strongly influenced by the temperature of the evaporating medium. Duff temperatures in the open have been observed as high as a hundred and forty-eight degrees Fahrenheit while air temperatures were between eighty and ninety degrees Fahrenheit.[8] Therefore, fuels in the open dry out much faster than fuels shaded by the forest canopy. Slopes that receive the sun' rays at close to a right angle heat up much more and dry faster than north slopes which receive the sun's rays at more oblique angles.

<u>THUNDERSTORMS</u>: Lightning is the only weather phenomenon which is the direct cause of forest fires. Because lightning results from thunderstorms these will be the only weather phenomenon covered here.

The fundamental thing required to form a thunderstorm is a strong upward current of air. This may come from a cold front, thermal lifting or orographic lifting.

When air rises it expands and in expanding it cools. If it cools sufficiently, the moisture in it becomes visible in the form of clouds. If the vertical currents are strong enough to carry these clouds up to an altitude where temper-atures are well below freezing, a thunderstorm is possible.

Small cumulus clouds are the forerunners of thunderstorms. They are composed of moisture. When these clouds build up to the freezing level, some of the moisture turns to ice particles, and these become the nuclei for raindrops. If the cloud continues to build, more raindrops form until finally they begin to fall towards the ground.

These raindrops start down, but the vertical currents catch the drops and break them up. In breaking up, the raindrops produce positive and negative ions of electricity. Now the cloud not only has moisture, but a static charge of electricity. When the charge builds up enough, it discharges in the form of static electricity. These charges go from cloud to cloud, or from cloud to ground in the form of light-ning.

A cloud can be lifted to freezing temperatures because dry air cools ~~at~~ five and a half degrees Fahrenheit for every thousand feet of rise and when it is cooled enough to become saturated it cools at only three degrees Fahrenheit for every thousand feet of rise.[1]

For thunderstorms to form, the air around the lifted air must be unstable. Altocumulus clouds along with cumulus clouds indicated this type of unstableness. Also thunderstorms usually follow movement of high temperatures at an interval of twelve to thirty hours after the maximum temperature.

The average number of days per year with thunderstorms is five along the Cascades and ten in Eastern Oregon.[5] Some places have an average of eighty thunderstorms per year, but Oregon with its dry summers has a worse fire hazard. On an average, lightning causes seven hundred and fifty fires a year in Washington and Oregon. General storms caused an average of thirty-five fires per storm day and a maximum of two hundred and fifteen. Local storms caused only one fire per storm day.[8]

It was found that lightning started fires in the following fuels in this order.[8]

1. Dead standing trees.
2. Live trees.
3. Needles and duff on the ground.

There was no difference between high and low altitudes in the number of lightning fires per acre when the storm frequently was the same.

INFLUENCE OF ALTITUDE ON WEATHER FACTORS: Because the energy that reaches the earth is transferred by radiation there is a decrease of temperature with altitude. Yet cool air is heavier than warm air and during periods of little surface heating the cool air tends to settle into the valleys. It was found in Idaho that maximum temperatures were higher by ten to seventeen degrees Fahrenheit and minimum temperatures lower by about four degrees Fahrenheit at valley stations than at higher mountain stations.[4]

Winds at higher altitudes are of higher velocities than those close to the surface.[7] This is due to the decrease in friction and surface eddies. The average daily wind velocity at mountain stations is about three times that shown at the valley stations.

Relative humidities closely follow the trend of temperatures. Relative humidity was lower at night and higher during the day at mountain stations than in the valleys. This causes night fires to burn better at high elevations than at low elevations.[4]

OTHER FACTORS: Evaporation takes place faster than the transfer of soil moisture to the duff during the day. Therefore soil moisture doesn't have any appreciable affect on moisture content of the duff in open areas during the day. Soil moisture does increase the moisture content of duff at night and under forest canopy during the day.

Fuels under forest canopies don't become damp with dew. The temperature of the duff under the trees isn't cooled by radiation, therefore the duff stays warmer than the air around it, and no condensation of water vapor takes place.

LONG TIME CHANGES

Data on long time changes is scarce, but such data ~~that~~ as has been collected in the Northern Rocky Mountain region has shown steady reduction in the annual precipitation for the past several decades. The finding indicate the following:[8]

1. The climate of Northern Idaho has exhibited distinct wet and dry periods, varying in length from twenty to forty years or more.

2. The forty years since forest fire protection was begun appears to have been the driest years of record.

3. Such variations are often overlooked in the practice of forestry.

Rainfall for the west half of the Northern Rocky Mountain region since the period 1900 - 1910 has decreased b by ten to thirty-four percent. The average reduction for all stations was about twenty-one percent up to 1940. Also there has been a significant increase in the mean yearly temperature.[8]

Long time fire protection planning should recognize and take weather cycles into account. Forester's, in working along the lines of fire protection, should see that accurate daily readings are kept and properly recorded for future uses.

VISIBILITY AND FIRE PROTECTION

For purposes of observation and record, visibility is the greatest distance toward the horizon at which prominent objects, such as mountains, buildings, towers, and other similar objects, can be seen and identified by the unaided eye. This distance depends upon the clearness of the air, and is modified by the turbulence of the air and by the presence of haze, dust, smoke, fog, rain, and snow. Visibility records are made by eye observations of stationary objects at known distances from the observer, and may be expressed in miles.

Atmospheric conditions affecting visibility assume great importance to fire protection authorities when they hamper the detection of forest fires. Poor visibility that might affect fire protection is caused by dry haze, smoke and dust or a combination of these. Daily records of visibility should be kept. These can be used as a basis for ground patrols or plane coverage in bad areas.

In planning lookout coverages, extra foot patrols or plane coverage, the chance for quick discovery should be taken into consideration. It has been found that smoke columns can be seen from further away when the observer is looking into a low sun than when he has the sun at his back. Smoke columns can be seen from further away on cloudy days than on clear days. Smoke against a green background is easier seen than against the sky.[8]

Factors influencing the lapse in time from start of fire to its discovery are as follows:

1. Atmospheric obscurity.

2. The background against which the smoke is seen.

3. The distance from the lookout to the fire.

4. The relative position of the sun with respect to the observer.

5. The behavior of the fire and the amount of smoke.

The average discovery time for fires seven miles distant, with a green background, was nine minutes. At twenty-five miles the average discovery time was thirteen and a half minutes.[8] Tests also show that smoke visibility is the poorest to the north, and where the country has light colored or mixed backgrounds there should be more intensive distribution of lookouts. At least there should be more intensive searches by the available lookouts and these should be supplemented by foot patrols or planes.

WEATHER FORECASTING

It has been shown how various weather factors affect the problems of forest fire protection. A picture of the fire situation at a given moment is of great value, but to have the picture as it is likely to appear in a few hours or days can be still more valuable. This permits planning to meet the changing situation. This knowledge of future weather can be obtained from forecasts.

The hope of being able to foresee future weather conditions furnished the main "push" to the development of the weather map and the organization of government meteorological services. The practical value of an accomplishment enabling man to more or less prophesy weather is evident. Daily forecasting is a matter solely of studying the weather map, including such upper air data as may be available. The weather map makes it evident that day-to-day weather is largely controlled by the movement and interaction of differing air masses and the resulting development and motion of cyclonic depressions and anticyclones. The primary fact in forecasting is that weather travels.

METHOD OF FORECASTING

Two methods of forecasting weather are in use. The first and oldest is by a study of pressure systems.[2]

At first the chief attention of forecasters had been centered upon the moving cyclones and anticyclones of the weather map, considered as entities. The chief effort had been given to estimating the paths and velocities of these highs and lows and their influence on the weather as they passed. Since the forces controlling their movement and changing intensity are unknown in detail, rules for forecasting are necessarily empirical. After a long and intimate familiarity with weather maps, the forecaster develops the ability to judge with cosiderable accuracy what changes in existing weather to expect under given conditions. This practice of forecasting, though based on certain fundamental physical principles and facts, is more of an art than a science.

The second and most recent method of forecasting weather is by analysis of air masses.[1] This method of weather analysis and forecasting has grown out of the polar front theory of the origin of lows and highs. In this method a study of air masses and discontinuities largely displaces the study of depressions and anticyclones.

In the analysis of air masses an effort is made to ascertain the following:

1. The extent and physical properties of each air mass.
2. The relations of the different masses to each other.
3. The location, structure and movement of the fronts along which the different masses meet.

The structure of an air mass includes such properties as the temperature, humidity and lapse rate at different levels; whether or not there is conditional instability; whether the air is stratified or well mixed; the existence of inversions, and whether these are due to warm currents aloft or to subsidence of the upper air. A knowledge of the structure along the front involves ascertaining the slope of the front, the difference in temperature between the two masses, and the extent of mixing and turbulence at their surface contact. Air mass analysis consists of a detailed study of the structure of the air. For successful application to forecasting, it requires frequent observations at the surface and also a network of observations aloft, by which means a third dimension is added to weather observations.

WEATHER CONTROL

Until quite recently man's efforts to control weather were quite feeble. Most of the efforts were efforts involving convection currents. Large fires were used to set up the convection currents. Little success was experienced.

In the past couple of years experiments with dry ice have been tried.[6] Conditions still have to be right, but more success has been attained by this method than by any other method. There has to be an abundance of moisture available which only needs nuclei for raindrops to form around. A dry ice crystal is an excellent nucleus for a raindrop and when air with an abundance of moisture is seeded the moisture collects on the nuclei and clouds are formed. The clouds now represent saturated parcels of air which has a lower cooling rate than the air around it. The cloud will now expand and build until it is cool enough to condense moisture from it. The condensation usually falls in the form of rain.

As far as forest fire work is concerned, this process of weather control does have valuable aspects and experiments may prove worthwhile. In the Cascades during the summer months, air that is right for thunderstorms is pushed up the mountains where it gets its necessary lift to set off a chain of reactions which results in thunderstorms. Such thunderstorms might be controlled by seeding the air with dry ice and causing the thunderstorms in a milder form to take place over the valley and not in the back inaccessible areas. This would help to control forest fires by cutting down the number of fires in areas hard to get to. On the other hand, such rain that might fall would help the farmer during the dry summer months.

FOREST FIRE-WEATHER SERVICE

In 1912 the United States weather bureau was informed of the need for special weather forecasts. In 1914 a fire weather warning service was put into service.[8]

The fire-weather service is conducted as an aid to the fire protection forces of government, state, and private agencies.[2] The control of forest fires is a difficult problem involving heavy expenditure of time and money and often services of large forces of men. The efficiency of fire control is largely dependent upon forestry officials' being prepared for emergencies as they arise. Since weather, more than any other factor, is responsible for the degree of fire hazard, forecasts covering those weather elements directly bearing upon the fire control problem are invaluable. It is evident that wind is an important factor in the spread of forest fires, and it is found that the relative humidity of the air is also very important, because of its influence on the inflammability of the forest litter. Many forest fires originate in the occurrence of lightning without heavy precipitation.

The plan of operations is to maintain meteorological substations within the forested areas, in many cases manned by Forest Service employees. During the seasons of hazard, reports from these stations are transmitted daily by radio, telephone, or telegraph to the headquarters of the forecaster for the district. These reports, in conjunction with the general weather map, are used as a basis for the formulation of specialized forecasts which are promptly distributed to fire-control officers. This service is in operation in all the principal forest areas in the country. In some places an automobile truck has been provided and fitted with meteorological and radio equipment capable of sending and receiving messages. This proceeds to every large forest fire, accompanied by a forecaster and a radio operator. Thus the forecaster is able to keep in close touch with the situation and to issue forecasts and advices closely localized and adapted to immediate needs.

SUMMARY

Objects of meteorology in forest fire protection are summed up as follows:

1. To provide localized weather forecasts to suit the needs of particular forest regions. This should include a study of local conditions, particularly in mountainous regions.

2. Forecasts should be for twenty-four to forty-eight hours ahead and as much longer as possible, and should cover rainfall, wind, temperature, relative humidity, thunderstorms and visibility.

3. The study of the possibility of long range forecasting should not be overlooked.

4. The continued co-operation between foresters and meteorologists is essential to the development of improved forest fire forecasts which leads to improved forest fire protection.

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