about 22 per cent too high, and when the instrument is adjusted to record correctly at the most frequent or average velocities, by changing the factor to 2.65, its rate is still 6 per cent too high at 25 miles an hour and 9 per cent too high at 100 miles an hour. Velocities indicated by the new standard are about 2 per cent too high at 25 miles an hour and 5 per cent too high at 100 miles an hour; as indicated in the Table 4, when the old standard is properly adjusted and indicates a velocity of 50, the true velocity is 46; when the new standard indicates 50 miles an hour, the true velocity is 48, etc.

It is expected that the new standard will be adopted as soon as instruments now in use can be modified and replaced. A description, including plans of the new anemometer, is in preparation for use by anyone interested in the operation or manufacture of these instruments.

WHY HARDWOODS DO NOT GROW NATURALLY IN THE WEST

By J. A. Larsen, Forest Examiner

[Excerpts from *The Idaho Forester*, annual, 1922, 4: 28-32]

Unfortunately the beautiful hardwood trees which are native to the Eastern States do not grow naturally in the West. We have here only aspen, cottonwood, small birch, hawthorns, cherry, and alder. On the Pacific coast are oak and maple, but limited largely to lower moist sites such as streams bed and canyons. The general absence of broad leaf trees in the West is most likely due to the difference in precipitation and temperature between the East and West. To be sure, there are other factors which limit the distribution of trees, such as soil acidity, alkalinity, soil and atmospheric moisture, as well as inherent qualities in the plants themselves. Soil acidity and soil moisture or quality of the soil can at best be of significance only within a limited area, and since it has been shown, except for areas near the sea, that atmospheric moisture varies according to the precipitation, it is only a result and, as such, not a controlling factor. Internal structure of leaves and stems, ability to transport much water, injuries by frost, etc., must be looked upon as direct results of the plant's environment rather than factors which control their distribution. There remains, therefore, the factors of temperature and precipitation and the variation and extremes of these worthy of consideration.

Air temperature, though it may not in all cases be a controlling factor, often limits the distribution of trees either by too short, too cold summer weather and frosts during the growing season, or by too great extremes. Experiments have shown that the leaves of trees do not become green in temperatures above 104° F. and do not function below 40° F. Unusually low temperatures may cause root killing, bark and wood splitting, and killing of buds and stems of hardwood.

If the growing season is too short, the species which are introduced from a warmer climate bud out too early in the spring, or have no time to form sufficient wood in the new stems to withstand frost injuries in the fall. If the nights are too cold throughout the summer months, one of the plant foods, sugar, which is not injured by freezing, has not had time to form before the cold weather sets in. The plant food is therefore chiefly in the form of starch, which is damaged by frost.

From the standpoint of water requirement of trees, it is well to note that the structure of the leaves, stems, and wood of trees may render some entirely unsuitable for certain climates, especially in regions characterized by dry summer air and low rainfall. Deciduous trees are able to transport much more water than conifers. Dr. Franz R. von Hohnel, of the Austrian Forest Experiment Station, determined by careful tests over a period of 12 years that 1 acre of oak forest lost by transpiration from 2,227 to 2,672 gallons of water per day during periods of growth. This is equal to 2.9 to 3.9 inches of rainfall per month for the growing season—much more than occurs over the western sections of the United States. Other broad-leaved trees are much like oak in respect to evaporation of water.

An examination of the distribution of hardwoods in the Eastern States shows that their general northern limit follows a line through St. Paul, Minn., to Eau Claire and Sheboygan, Wis.; Grand Rapids, Lansing, and Detroit, Mich. North of this line the forest is predominantly coniferous. From Detroit to central New York an inversion occurs in that the hardwoods are on the north and the conifers to the south. This is evidently due to low land and relatively warm air surrounding the Lakes and the higher land with colder air to the south. From central New York the line goes northeast through western Massachusetts, through Concord, N. H., and Augusta, Me., with conifers on the north and hardwoods to the south. The westward extension of the hardwoods is defined by the Mississippi River from St. Paul to Rock Island, Ill., thence southwestward through Iowa, Kansas, and Oklahoma, irregularly, according to local variations in topography.

In conclusion it may be said that precipitation and atmospheric moisture over the western United States are insufficient for the eastern hardwoods. Air temperature is suitable in most towns and cities and over extensive farming sections. This makes it possible by irrigation or by planting in certain very favorable sites such as moist slopes and aspects sheltered from the driving summer winds, to raise eastern hardwoods in the Pacific Northwest. Except for southern Idaho and the Pacific coast cities, however, the frequent frost which occurs over most of the region during late spring and early fall are a serious drawback, which stunts and kills back the young trees and retards growth on the mature trees.

[Charts showing the mean air temperature and rainfall for different eastern and western cities accompany the article showing the distinction spoken of in the test.]

551.524 : 632

TEMPERATURE SUMMATIONS WITH REFERENCE TO PLANT LIFE

By G. A. Pearson, Director

[Fort Valley Forest Experiment Station]

Plant investigators are seeking an index of temperature which is expressive of the heat conditions required by plants. The mean temperature generally employed by meteorologists and too often by biologists is misleading when applied in the vegetable world. Plants are far less concerned with the relatively low night temperatures than with the more effective temperatures prevailing during the hours of daylight. For this reason a mean which gives equal wieght to night and day temperatures is a poor measure of the heat available for maintaining the physiological processes involved in plant life. The inadequacy of mean temperature is very evident in the mountain forests of the Southwest, where an extremely high daily range is the rule and where the native vegetation experiences little discomfort from low night temperatures even to the point of frost, but is exceedingly dependent upon heat energy for carrying on photosynthesis.

During a period of three years a series of meteorological stations in the vertical was maintained in the San Francisco Mountains of northern Arizona. The lowest of these stations was in the woodland or piñon-juniper belt at about 6,500 feet elevation. From here on up the mountain slope, one or more sets of instruments were installed; in the yellow-pine forest 7,300 feet; in the Douglas-fir forest at 8,700 feet; in the Engelmann-spruce forest at 10,500 feet; and finally near the upper limit of tree growth at 11,500 feet. Figure 1 shows decided irregularity in the graphs of mean temperature. This is particularly evident in comparing the graphs for the yellow-pine and the Douglas-fir forest. The Douglas-fir station, situated 1,400 feet above the yellow-pine station, gave a mean annual temperature only 0.7° F. lower than that of the latter. From December 1 to June 30, the monthly means for Douglas fir were often as high or higher than the corresponding records for yellow pine. In January the Engelmann-spruce forest, situated nearly 3,000 feet above the yellow pine, recorded the same mean temperature as the latter.

A glance at the mean minimum graphs shows at once that this is the source of disturbance. During every month of the year the yellow-pine station has a lower mean minimum than the Douglas fir, and in 8 months out of 12 it is below the Engelmann spruce. This phenomenon, which is well understood by meteorologists, is due to drainage of cold air off the mountain slopes and settling at the base where the yellow-pine station is situated.

Turning to the graphs (fig. 1) of mean maximum temperature, we find almost perfect coordination between the various stations. The days are invariably warmest in the lower altitudes. Here also we find the plants known to have high heat requirements. In every way the mean maximum temperature seems to furnish a reliable expression of heat relations in the various forest types. Throughout Arizona and New Mexico, wherever high mountain records are available, the same relative conditions have been found. When dealing with mean and mean minimum temperatures, inversions are the rule at stations situated on plateaus or in valleys at the base of high mountains; but inversions disappear in the mean maximum. The foregoing observations have led the writer to regard the mean maximum as a far better index of temperature than the mean, when plant life is under consideration. It is gratifying to find that the more recent summaries published by the Weather Bureau include the mean maximum temperature.

Various schemes have been devised to express in a single figure the total amount of heat available for plant growth during the growing season. One of the earliest attempts was that of Merriam, who, assuming that no appreciable activity in plants takes place when the mean daily temperature is below 43° F., added together the degrees of mean daily temperature above this minimum. Some of the obvious objections to this method are: (1) That the minimum temperature for growth varies greatly in different plants; (2) that growth is not directly proportional to temperature, and (3) that the computations are based upon mean daily temperature which has been shown in this paper to be a very uncertain quantity.

Where thermograph records are available it is possible to determine the mean temperature for each hour of the day and thus make an accurate summation of effective temperature according to any adopted standard. A simple though fairly effective method provides a means of analyzing temperature by merely adding together for each day the number of hours with temperature between any fixed limits. Thus it was found that in the spruce forest of the San Francisco Mountains the temperature curve rose above 70° F. only during four hours in the entire growing season (June–September) of 1918; during the same period the number of hours above 70° F. was 134 in the Douglas-fir forest and 633 in the yellow-pine forest. A decided improvement on this method could be attained by taking the product of intensity and duration, or what amounts to the same thing, by planimetering the space described by the thermograph curve and any fixed temperature line.

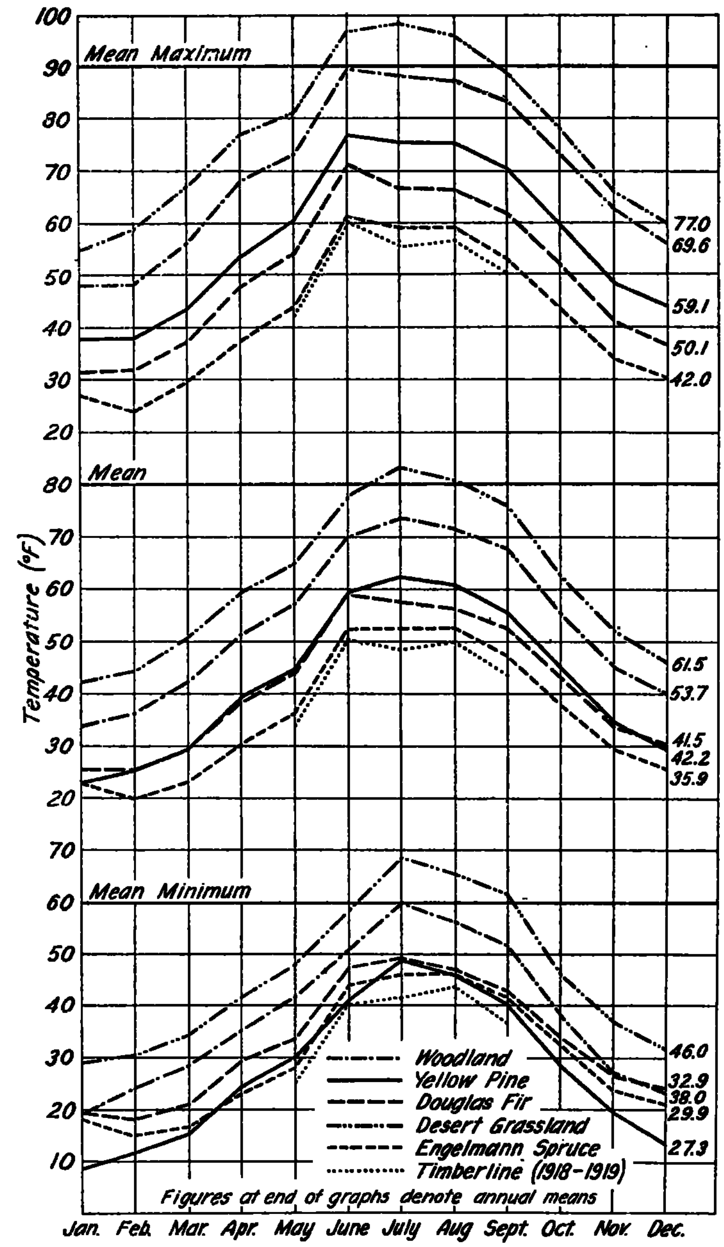

FIG. 1.—Temperature by forest types in northern Arizona

A marked advance over the foregoing schemes is made by what is known as the method of physiological indices of temperature efficiency. It is based upon experiments by Lehenbauer, in which he determined the hourly rate of growth of maize seedlings exposed to the same temperature during periods of 12 hours. The values thus obtained formed the basis for a table giving an index of efficiency for each degree in the centigrade scale. Livingston has worked out the corresponding values for the Fahrenheit scale. Taking the efficiency at 40° F. as unity, it rises rapidly with temperature until a maximum of 122 is attained at 89° F., beyond which point the values decline.

Proper application of this method calls for a better measure of temperature than is afforded by the daily mean. Lehenbauer's experiment was conducted with plants exposed to constant temperatures. The index of efficiency corresponding to a given daily mean temperature may be far different from that obtained by summing the indices for the components of this mean. Where thermograph records are available, a far more accurate though rather laborious process is to determine the index corresponding to the mean temperature for each two-hour period and taking the average of the values thus obtained. This eliminates practically all of the periods of ineffective temperature instead of combining them with periods of effective temperature and thus reducing the value of the whole. The two-hour period has been chosen as a compromise between accuracy and expediency. Intervals of one hour or even less would yield more accurate results but at the expense of greatly increasing the work of compilation. In Table 1, indices obtained by averaging two-hour periods are compared with those derived from the daily mean temperature. Figure 2 shows the relative temperature efficiency in the various forest types of northern Arizona referred to the growth of maize seedlings. It will be observed that although based upon records of a single season the graphs, as in the case of mean maximum temperature, show a very consistent relationship between the forest types.

TABLE 1.—*Physiological temperature efficiency*

[Yellow-pine type]

June, 1918	Daily temperature		Physiological efficiency based on—	
	Maximum	Mean	Daily mean temperature	Temperature by 2-hour periods
	°F.	°F.		
1	68.8	52.8	9.22	17.22
2	75.5	54.2	10.33	28.01
3	75.7	56.5	14.44	31.23
4	77.0	56.3	12.78	37.97
5	76.2	57.05	14.44	38.73
6	79.0	58.45	16.11	39.04
7	77.7	60.25	19.88	41.22
8	77.5	59.65	19.88	37.47
9	83.0	63.25	27.11	51.50
10	86.3	67.15	41.33	56.97
Total	776.7	585.6	185.52	379.36
Mean	77.7	58.5		
11	88.9	68.85	50.83	66.12
12	88.2	68.0	46.00	45.87
13	81.9	66.4	37.22	44.29
14	81.2	65.45	33.33	40.56
15	76.6	61.95	24.33	31.22
16	76.9	62.5	27.11	31.99
17	81.0	66.25	37.22	37.77
18	79.0	63.35	27.11	34.54
19	78.0	63.45	27.11	31.71
20	79.0	63.35	27.11	43.10
Total	810.7	649.55	337.37	407.17
Mean	81.1	64.96		
21	77.8	66.15	37.22	28.80
22	70.0	61.15	22.00	21.00
23	73.5	62.75	27.11	28.65
24	77.6	61.4	32.00	33.47
25	81.0	64.75	33.33	44.46
26	86.3	67.4	41.33	61.48
27	86.5	70.5	60.83	68.45
28	86.8	65.7	37.22	55.90
29	83.5	66.25	37.22	42.95
30	82.1	64.05	30.00	36.46
Total	805.1	650.10	347.76	421.62
Mean	80.5	65.01		
Monthly total	2,392.5	1,885.25	870.65	1,208.15
Monthly mean	79.8	62.8		

Since plants vary in their heat requirements, indices of efficiency should be determined for each species concerned, or at least for several groups of species having approximately the same requirements. In forestry, for instance, separate determinations should be made for characteristic species such as western yellow pine, Douglas fir, and Engelmann spruce.

Of all the methods here described, the method of physiological indices is the only one which is based directly on the response of plants to heat. This method promises to be very useful when supported by thermograph records and experimental data on the response of various species. Without these data, however, the values obtained are only a rough index. Under these circumstances, which indeed are those generally encountered, the mean maximum temperature is believed to be the most practical index available. In the mountains of the Southwest it has proven far more consistent and expressive than mean temperature, and while it may not prove equally superior in regions of low daily range and higher temperatures generally, it will undoubtedly prove a valuable adjunct to records of mean temperature. As

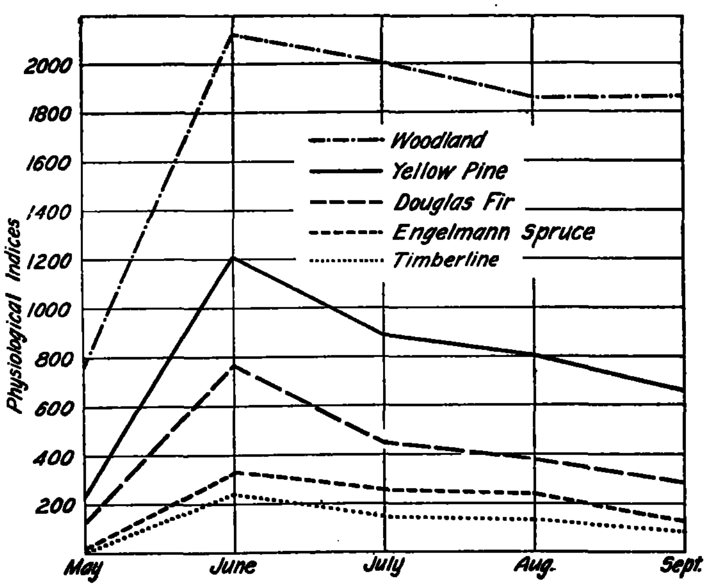

FIG. 2.—Physiological tempetraure efficiency, 1918

compared to the method of summing daily means above 43° F. or any other minimum limit, it has the advantage of greater simplicity and consistency.

In conclusion I wish to recommend to ecologists that they consider the mean maximum temperature where thermograph records are not to be had. Obviously, the mean maximum is to be regarded only as an index rather than a complete measure of heat conditions. To Weather Bureau officials I wish to suggest that they use every effort to include the mean maximum in their temperature summaries.

551.5 : 621.396

OUR PRESENT KNOWLEDGE CONCERNING THE ATMOSPHERIC DISTURBANCES OF RADIOTELEGRAPHY [1]

L. W. AUSTIN [2]

[U. S. Naval Radio Research Laboratory, Bureau of Standards, Washington, D. C.]

Our present knowledge concerning the atmospheric disturbances of radiotelegraphy is very limited, but in the following I have attempted to make a brief résumé of the known facts and generally accepted hypotheses.

[1] Subreport of committee on atmospheric-electric phenomena and measurements in the troposphere and stratosphere presented at the annual meeting of the section of terrestrial magnetism and electricity of the American Geophysical Union, Apr. 18, 1923.

[2] Reprinted from Bull. of the National Research Council, vol. 7, pt. 5, No. 41. Washington, 1924, pp. 127–130.