THE AGRICULTURAL SIGNIFICANCE OF SUNSHINE AS ILLUSTRATED IN CALIFORNIA.

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SYNOPSIS.

Sunshine is important in plant growth because the heat and the light required by all growing plants are supplied by solar radiation. While heat can not entirely replace light in this process, light can in large measure replace heat. The quality and the quantity of the sunlight transmitted to growing plants are both dependent upon atmospheric conditions, as well as upon the season of the year. They vary from place to place and from month to month.

Of the various weather elements, sunshine, directly through radiation, and indirectly through its effect upon air temperatures, influences the distribution of crops. Because it furnishes the required energy for certain chemical activities within growing plants, as well as promotes evaporation from the foliage, abundant sunshine is required of most plants. Partly because of the power of water vapor in removing certain chemically active rays from the sunlight transmitted through the air, humid regions are best adapted for certain crops, and wholly unfitted for other crops.

California is a State of vast size, and shows extreme diversity of topography, soil and climatic conditions. Sunshine varies greatly in quality and in quantity in different parts of the State. Horticulture, the most important branch of California agriculture, is practiced to best advantage in those portions of the State where the amount of sunshine is at a maximum. For all stages of the fruit, from the blossoming of the trees to the sun-curing process of the fruit, abundant sunshine is beneficial.

The sun curing of fruit, which is both a physical and a chemical process, is an important industry in California. Unbroken sunshine and absence of summer rainfall make the interior valleys the deciduous and citrus fruit centers of the United States. The earliest oranges to ripen in the State are those northern grown, a fact partly due to the increased amount of sunshine received during the summer season.

The dehydration of vegetables, a new industry in California, is making rapid progress. The State is well adapted for this, as abundant sunshine favors the growth as well as the curing of vegetables. Beans grow to best advantage along a narrow belt of the coast, largely because diffused rather than direct sunlight is required. Moreover, the plants thrive under humid conditions and frequent fogs, from which they absorb some moisture. Flower and vegetable seeds, on the other hand, require an abundance of sunshine and dry air, and are therefore raised to best advantage in the sheltered valleys.

California merits the appellation, "The Sunshine State," for the abundant sunshine forms the basis of agriculture, the State's principal industry. The agricultural crops of 1918 were valued at $645,000,000.

INTRODUCTION.

Because of the vastness of its size, its varied topography, and the diversity of its climate and its soil, California agriculture shows an epitome of that of the whole United States. This State has samples of every part of the world which permit successful agriculture. An enumeration of California fruits alone is a catalogue of the known fruits of the world, with the exception of those strictly tropical. This is also true of certain individual countries, which in several instances are larger than whole States.

While in most States the crop-growing season is limited to six or seven months in the year, in California the entire year constitutes the agricultural period. Crops are growing and maturing all the time within the State. There is a continuous seedtime and harvest for something, and there is but occasional coincidence with eastern crop periodicity. There are wider differences within its borders than are found in a long sweep of States from the Gulf of Mexico to Canada. In latitude, California extends from 33° north to 42° north, corresponding roughly with that from Charleston, S. C., to Boston, Mass., on the Atlantic coast of the continent. Owing to the proximity of the Pacific Ocean, and the prevailing westerly direction of its winds, the isotherms run north to south, not east to west, as in the interior of the continent. The mean annual temperature ranges from 42° F. to 76° F., while extremes of −21° F. and 134° F. (the highest natural shade temperature recorded anywhere on the earth's surface) have occurred in different parts of the State in the same year. The mean annual precipitation ranges from 2 inches to 113 inches, with extremes at different stations ranging from no rainfall to 154 inches. Altitude above sea level rather than latitude controls the temperature, while altitude together with latitude control the precipitation. The southern and lower portions of the State are drier than the northern and higher portions. Summer and winter are terms synonymous with dry and wet seasons, respectively, rather than with warm and cold seasons. About 90 per cent of the total annual precipitation occurs between October 1 and March 31. Topography is of more importance as a control of climate than is latitude, and the State contains the highest as well as the lowest points in the United States.

Sunshine, the only element of climate here considered, varies greatly in amount from month to month, as well as from county to county. California has been termed "the sunshine State," but the title is not equally merited by all portions of the State. While cyclones control the weather, their transcontinental paths are deflected so far to the north during the summer half-year that the State then enjoys subtropical, rainless conditions. The interior valleys then receive the maximum possible amount of sunshine, and practically cloudless skies sometimes prevail for several successive months. On the other hand, the indraught of cool, westerly winds from off the ocean brings in fog along the coast, which penetrates 10 to 20 miles inland every night, but which is dissipated to some extent during the day. On exposed places like Point Reyes the sun during midsummer sometimes remains invisible on account of fog and low cloud for more than three weeks at a time. Under these varied conditions of cloud and sunshine the State sometimes has the highest and the lowest temperatures in the United States during midsummer.

The climates of California may be roughly classified as (*a*) coast; (*b*) valley (including foothill); and (*c*) mountain.[1] With particular reference to sunshine, these may briefly be described as follows: The coast climate is one of equable temperature, with relatively cool summers and relatively warm winters; abundant rainfall, increasing from the south to the north; humid atmosphere at all times, with much fog and cloud, and hence with deficient sunshine, particularly during the summer half-year. In spite of the almost saturated condition of the atmosphere during the summer, measurable precipitation is then negligible in amount. The valley climate is one of high summer and low winter temperatures, with deficient rainfall in the south, increasing to abundant in the north; extremely dry air and almost unbroken sunshine during the summer; and only a moderate amount of cloudy and rainy days during the winter, with comparative freedom from fogs. The foothill climate, that of places up to 2,500 feet in elevation, differs from the valley climate principally in its smaller ranges of temperature and a slightly higher annual rainfall. The valleys and foothills together form the principal agricultural portions of the State. The mountain climate is one of moderately warm summers and moderately cold winters, abundant precipitation, increasing with altitude up to about 5,000 feet, and abundant sunshine, particularly during the summer half-year.

[1] Cf. W. G. Reed, Climatic provinces of the Pacific coast, *Bull. Am. Geogr. Soc.* (New York), Jan., 1915, 47: 1–19, 4 figs. (Review, *Science*, Aug. 20, 1915, N. S. 42: 251.)

SUNSHINE AND HORTICULTURE.

Horticulture is the leading agricultural activity in California, and its importance is constantly increasing. Since the terms northern and southern have little climatic and no agricultural application here, northern fruits reach perfection, under proper conditions, at the south, and vice versa. In the words of Prof. E. J. Wickson, of the college of agriculture of the University of California:[1]

> The apple and the orange, fruit kings whose kingdoms lie at opposite borders of the Temperate Zone, so far distant that one may be called semifrigid and the other semitropical, have in California utter disregard for the parallels of latitude, which set metes and bounds upon them in other lands, and flourish side by side, in suitable localities, from San Diego to Shasta.

Moreover, some fruits can be successfully grown through a north-south distance of 500 miles, but can not successfully be carried through a few hundred feet of either less or greater elevation. Occasionally, snow-clad mountains and groves of delicate orange trees are in close juxtaposition laterally, though at different altitudes above the level of the sea.

The meteorological conditions under which fruit growing is most successfully carried on in California are primarily (*a*) abundant sunshine, (*b*) low atmospheric humidity, (*c*) absence of extremely low temperatures, and (*d*) generous soil moisture, largely supplied by artificial irrigation. Through a combination of these conditions, fruits are found to grow to best advantage in the valleys and on the foothills and lower mountains. Because of the deficient sunshine and the excessive humidity fruits are not grown in commercial quantities on the immediate coast. Direct and not diffused sunshine is necessary for ripening some fruits, but still more is needed for their curing and preserving. The excessively low relative humidity of the atmosphere over the interior valleys during the daylight hours of summer permits the penetration through it of an intense sunlight. This results in a maximum physical as well as chemical action on the growing fruit. The physical heating of the plant tissue is promoted, and the evaporation of part of its water is accelerated. In addition, the growth of some microscopic parasites is checked, and certain ripening processes of the fruit are hastened. Favorable comment is often made concerning the absence of certain parasites and the excellent keeping qualities of California fruits. While in a measure this is due to fumigation and the artificial application of germicides, it is also partly due to the beneficial effects of the sunshine to which the maturing fruit is subjected during the long, cloudless summer. The distinctive flavor and the characteristic aroma of California fruit can also be explained in the same way. The extreme dryness of the air promotes evaporation, and hence aids the flow of sap in the trees.

The horticultural year begins with the blossoming of the almond trees in January, an event which marks the advent of spring in California. The period of greatest fruit growth is from May to September. Deciduous fruits are harvested chiefly during the same months; citrus fruits are harvested chiefly from December to June. The rest period in trees and vines is a dry season climatically, not a cold season as in the East. The autumn rains usually begin in October. The character of the autumn, particularly with reference to rainfall, determines in large measure the size and the quality of the fruit crop of the following year. An interesting example of this relation is apparent in the 1919 deciduous fruit crop, which is the largest crop of this kind ever grown in California. During September, 1918, the heaviest rains recorded in a month of September in California during 69 years of record were general throughout the central portions of the State.

That sunshine is of prime importance in fruit growing may be seen from its influence in all stages of the fruit, from blossoming to maturity. During the blossoming period of deciduous fruit trees, principally February to April, inclusive, there is usually enough sunshine each year to produce a satisfactory set of fruit. The winter rains are decreasing in frequency and in amount during this period. While there may be cloudy and rainy days during the blossoming period of any one kind of fruit tree, these conditions are rarely so long continued as to prevent proper pollenation. The temperatures are then so high that bees and other pollen-carrying insects may be expected to fly. After the fruit has set, its early growth is accompanied by longer and longer days, more and more sunshine, with increasing intensity. When the sun reaches its maximum altitude about June 21, cloudless skies occur every day. In the fruit-growing regions it not infrequently happens that 100 per cent of the possible sunshine is received during June. As the chemical qualities of the sun's rays are also probably at a maximum during June and July, all deciduous fruit makes rapid progress toward maturity. (During hot July weather in Iowa the farmers say "It makes the corn grow;" in California the fruit growers say "It puts sugar in the prunes." Cloudless skies usually continue during the harvest of the fruit. That to be consumed as fresh fruit is shipped in express refrigerator cars which move eastward in trainload lots on fast freight time schedules. That which is to be dried is placed upon wooden or paper trays and exposed to the hot sunshine.

THE SUN-CURING PROCESS.

The sun curing of fruit in California is a great industry. The unbroken sunshine and the absence of rain during July, August and September make possible the sun-curing of thousands of tons of fruit every year. The latter consists principally of raisins, prunes, peaches, apricots, pears, and apples.

Raisin grapes are grown chiefly in the San Joaquin Valley, Fresno being the center of the largest and most important raisin district in the United States. Grapes are not considered fit for raisins that do not contain at least 22 per cent of sugar. Before picking, the actual sugar content of the grapes is determined by the use of the sacrometer. If it is below 22 per cent, picking is postponed until that proportion has been reached, which is usually during August. Before the crop is completely harvested, the grapes test from 24 to 26 per cent sugar, which is the proper proportion to make the best quality of raisin.

The fruit is allowed to remain in the sun until all visible portions of the fruit are brown. As soon as this stage is reached the trays are immediately stacked. The berries are still soft, and contain considerable moisture which evaporates slowly in the shade or stack drying process, leaving the fruit in far better condition than if completely cured in the sun. This shade drying takes from two to three weeks, according to the weather. The increased humidity, which is apparent toward the latter part of September and the early part of October, also improves the condition of the stems, allowing the sorting of layers with very little breakage.

[1] E. J. Wickson, "California Fruits," p. 19.

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FIG. 1.—A California almond orchard in full bloom. The blossoming of the almond trees in January marks the advent of spring in California.

FIG. 2.—A Santa Clara Valley prune orchard in full bloom. San Jose, the largest city in this valley, ships more prunes in the course of a year than any other city in the United States. The weather conditions prevailing at the time of blossoming and setting of the fruit are of great importance in determining the size and quality of the crop.

FIG. 3.—Blossoming prune trees in the Santa Clara Valley of California.

FIG. 4.—Prunes being sun cured in the Santa Clara Valley of California. This region produces more prunes than any other region of equal size in the world. Because the prunes are sun cured, and not dried in artificial driers by means of artificial heat, Santa Clara Valley prunes have a most delicious flavor, and sell for higher prices than those grown elsewhere.

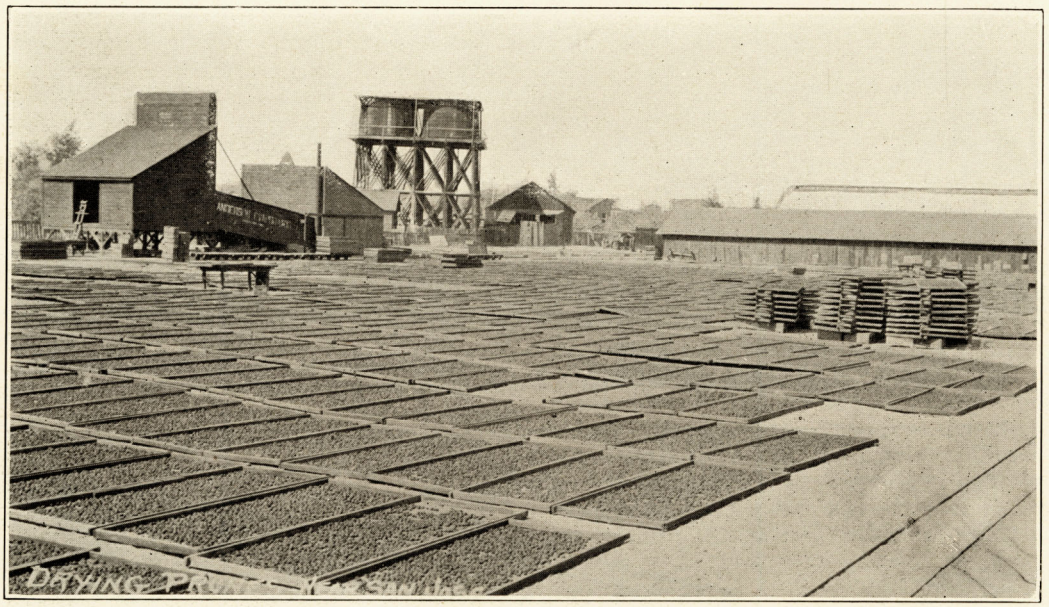

FIG. 5.—Prunes exposed to the hot sunshine on wooden trays in the Santa Clara Valley of California. Two to three weeks are required to complete the process. Weather conditions are all important at this time. When rain is anticipated the trays are stacked and covered. The official weather forecast is therefore of prime importance, and is eagerly watched for every day.

Prunes, a species of plum, are grown chiefly in the Santa Clara Valley, San Jose being the center of the largest prune district in the United States. The mature prunes are bathed in dilute lye solution, which softens and sterilizes the skin. They are then thoroughly washed and subsequently are spread on trays in the hot sunshine. After a week or two, water is almost entirely evaporated, and the sunshine has turned the red flesh of the prune to a black color, and the juices are largely converted into sugar. Sun-cured prunes have a characteristic flavor, and sell for a higher price than those artificially dried.

Peaches, apricots, pears and apples are grown in many valleys of the State. On maturing, these fruits are subjected to sulphur-dioxide gas, which has a germicidal effect, and also causes a chemical reaction which preserves the flesh of the fruit, and prevents if from turning black.

The sun curing of fruit is thus a physical as well as a chemical process. The intense sunshine, aided by the excessively dry air, promotes the evaporation of superfluous water, and converts the juices into sugar and other solids, of great nutritive value. The compactness of dried fruit and its excellent keeping quality make it one of our most valuable food products. A pound of raisins contains more nutrition than a pound of beef steak, and costs much less.

During the fruit-curing season there is naturally much interest in the weather, for on rare occasions rain falls upon the exposed fruit, doing immense damage. The official weather forecast is therefore eagerly looked for each day. When rain is anticipated, the trays containing the partially cured fruit are stacked and covered until danger of precipitation is past. (The confidence of the fruit grower in the Weather Bureau is well illustrated by the following incident. The writer was temporarily in charge of the local office of the Weather Bureau at San Jose during a part of August, 1919. On the morning of Aug. 28, when several thousand tons of prunes were exposed on trays in the Santa Clara Valley, the sky looked threatening. Within a period of three hours a total of 66 telephone requests for the weather forecast were received, and in addition many persons, including the editor of the evening newspaper, called at the office in person in order to secure the latest available information. The forecast of no damaging rain was fully verified, and the growers were thus saved the labor and expense of stacking the thousands of trays.)

Rain to the amount of 0.25 inch or more will do no damage to the drying fruit provided that sunny, drying weather follows within a day or two. But even a light shower, if followed by several successive days of cloudy and damp weather, will produce mildew and rot, which will damage or even destroy the food value of the fruit. Under ordinary conditions, however, every day during August and nearly every day during September is clear and dry. When every day is sunny, the fruit will be cured in one to three weeks, depending upon the kind and the condition of the fruit. The Weather Bureau offices at Fresno and San Jose are of particular importance during the fruit-curing season.

A new industry, which is destined to grow rapidly, has recently appeared in California. This is the dehydrating of vegetables. Sunshine plays an important part both in the production of the vegetable and in its dehydration. The first experiments on a commercial scale in the dehydration of vegetables were made by a California hop grower about 1915, who saw in the spread of the prohibition movement the extinction of hop growing as a profitable industry. The experiments proved to be so successful that before the close of the World War several hundred tons of dehydrated vegetables had been ordered by the commissary departments of various allied armies. At the present time the United States Department of Agriculture is spending $250,000 in informing the consuming public as to the merits of dehydrated vegetables.

In this process of dehydration the vegetables are dried either in special driers, with artificial heat, or they are sun cured, as is the fruit. The vegetables most commonly dried are potatoes, cabbage, onions, beets, beans, and peas. Through physical and chemical changes the pulp is reduced to a compact and dry mass, which, when properly packed and stored under satisfactory atmospheric conditions, will keep for years. When a housewife wishes to prepare the dehydrated vegetables for use, the dried product is first soaked in water, and then cooked as usual. After a short time it is ready to serve, with a flavor and an aroma as though fresh from the garden.

SUNSHINE AND CITRUS FRUIT.

The importance of sunshine is well illustrated in the growing of oranges, California's most valuable fruit crop. The dark-green foliage of growing orange trees absorbs most of the heat and light received from sunshine, but little of either being lost through reflection. The fruit makes slow but steady progress during the long clear days of summer and autumn, and the principal harvest comes in the winter and spring. Every effort is made by the orange growers to accelerate the maturing of a portion of the early crop in order that oranges may reach the eastern markets in time to catch the Christmas trade, and, if possible, the Thanksgiving trade. In this attempt to reach an early market, when the demand is high and when fancy prices are obtained, there is intense rivalry between the orange growers of northern and of southern California. Primarily because of the greater amount of sunshine received during the summer growing season, the northern California groves have produced the first carload lot of oranges during the autumn of each of several past years. This is an eagerly sought honor, and the record of northern California is all the more impressive when it is realized that southern California produces the great bulk of the orange crop, and has a warmer and more equable climate.

SUNSHINE AND VEGETABLES.

Another interesting example of the influence of sunshine, or rather the lack of it, is apparent in the production of the greater part of a large bean crop along a narrow strip of coast, extending principally from San Francisco southward to the Mexican border. The climate of this region is characterized by equable temperatures, increasing from north to south; relatively cool summers and relatively warm winters; moderate rainfall, increasing from south to north, but limited almost entirely to the winter months; prevailing westerly winds; and a humid atmosphere, with frequent fogs and overcast skies, particularly during the summer. While the soil conditions of this region are not greatly unlike those of other portions of the State, this narrow belt produces beans of many varieties, the bulk of the State's great bean crop. It appears that the bean plants extract some moisture from the humid atmosphere and the dense fogs, though little or no precipitation is recorded during the growing season. The sunshine received is that which has traversed a humid and cloudy atmosphere. The light transmitted to the plants, therefore, is rich in the qualities characteristic of the middle portion of the solar spectrum, but deficient in those qualities

characteristic of rays of either end of the spectrum. The bean crop is harvested principally in the autumn, which brings the maximum amount of sunshine this region receives during any season of the year. The crop is sun-cured, and the dried beans are separated from the pods by means of thrashing.

Partly because of differences in the amounts of sunshine received, sugar beets grown for seed are cultivated in one region, while those grown for the beets are produced by another portion of the State. (Previous to 1915 most of the sugar-beet seed was imported from Germany.) Vegetables are grown in commercial quantities principally in the humid valleys bordering the coast. A very large crop of potatoes is grown in the delta district near the mouth of the Sacramento River. In this restricted region summer temperatures are not so high as in the more interior valleys, and evaporation is relatively small. Sunshine is reduced in amount, and of a peculiar quality adapted for vegetable growth.

The growing of flower and vegetable seeds is an important part of California agriculture. A considerable proportion of the flower and vegetable seeds of the United States is grown in this State. For some particular varieties, practically all of the seed produced in the United States comes from California. In general, much sunshine and a minimum of atmospheric moisture are the conditions best suited for seed production. These conditions are particularly desired during the summer harvest season, when the crops are sun cured, and the seeds are extracted by means of thrashing machinery.

That the people of California are not unmindful of the significance of sunshine as a resource is evident from the great frequency with which the word sun enters into their vocabulary. In this "Sunshine State" we have "Sunkist Oranges," "Sun-Maid Raisins," and "Sun-Sweet Prunes." Most of these are shipped eastward over the "Sunset Route." As it is recognized that sunshine is the best natural germicide, enterprising real estate dealers advertise "Sunlit Homes." Life is largely in the open. In southern California many people practically live out of doors and are known as "Sun-Worshipers." Both in attracting tourists and in aiding agriculture, sunshine is one of California's most valuable natural resources.

PROJECT FOR LOCAL FORECAST STUDIES.[1]

By R. H. WEIGHTMAN, Meteorologist.

Weather not only affects persons in all walks of life, but is a controlling influence in every phase of human endeavor. On the condition of the meteorological elements depends the convenience and success with which our daily tasks and pleasures are accomplished—from the child who is laying the foundation of his educational structure to the business and professional man engaged in the prosecution of useful pursuits. The fact that weather and its effects are of universal interest is as true to-day as in the past. As a natural and logical sequence to this universal and time-honored interest experienced by mankind as a whole, weather changes have been impressed on his attention, thus laying the foundation for the many dictums and proverbs, associated with nature's signs as revealed in the clouds, sunsets, the moon, and in the habits and actions of animals and plants that we have to-day. Some of these sayings have a more or less sound physical basis, while others are grounded in fancy and superstition. Nevertheless, they have been handed down from generation to generation without distinction, until they have gained an entirely false significance in the public mind, especially among those who have not had the occasion and inclination to actually compare the saying on the one hand with the occurrence of the meteorological phenomena on the other.

As the science of foretelling the weather has progressed, meteorologists have gradually discarded the consideration of local signs and influences as indices of subsequent weather in favor of the surer, sounder, and more accurate indications of the weather charts which depict simultaneous conditions over wide areas. In fact, they have gone so far in this direction that, at the present time, scant attention is paid to purely local conditions in the preparation of forecasts, although any one familiar with local signs must admit that, at times at least, they are exceedingly valuable and important.

In 1883 a treatise on "Weather Proverbs" was published by H. C. Dunwoody, and in 1903 Prof. Garriott presented his bulletin on "Weather Folk Lore and Local Weather Signs" which brought together many of these old dictums and sayings. Later, Prof. Humphreys, in an article entitled "Some Weather Proverbs and their Justification" which appeared in the May, 1911, issue of Popular Science Monthly gave some interesting and instructive views on the physical reasons and principles underlying some of them.

A table showing the probable character of the weather based on the barometric pressure and wind direction is given in the bulletin by Prof. Garriott, while in the MONTHLY WEATHER REVIEW numerous references to clouds as indicators of the subsequent occurrence of precipitation have appeared from time to time. Officials of the Weather Bureau have prepared tables showing the relation of temperature, humidity, wind direction, pressure, pressure change, clouds, etc., to subsequent weather but, from the fact that results obtained by these methods were not so reliable as those based on the daily weather charts, such schemes have not been widely appreciated, nor have they been very much used.

Although as a rule local conditions play a rather unimportant rôle in the preparation of the general forecasts, yet there are times when the results to be expected from the weather map are extremely uncertain and doubtful, and at such times the forecaster grasps at any indication that may give him a clue to what weather may be expected to follow. Only recently Maj. E. H. Bowie proposed that the relation or bearing of all the weather elements, or combinations of them, be brought together into a single index or probability number, the influence of the different elements being proportionally weighted and, provided such a plan prove feasible, that such information be included in the telegraphic report of observations. Such a scheme would be on a strictly statistical basis and would not involve in any way the personal equation of the observer. It has been contended that such a scheme has advantages in mountain and coastal regions but that it would not be suitable for use in level areas with continental climates where the local signs that might be considered as indications of local weather changes are merely the usual results of well-known meteorological laws. While the latter is true, it is patent that, as long as conditions undergo changes, the question is how far

[1] Read by title, American Meteorological Society, Washington, D. C., Apr. 22, 1920.