earth was quite different from that which obtains at present.

Baron d'Hamonville next made an eloquent plea for protection to the birds of paradise and appealed to the ladies for support in this movement.

Dr. Herbert H. Field (Brooklyn) transmitted to the Congress a proposition of Prof. E. L. Mark, Cambridge, U. S. A., to "consider the desirability and feasibility of constructing a code of abbreviations in animal morphology based upon Latin names and to be recommended for general use by zoölogists and anatomists throughout the world."

The Congress voted unanimously that Sir William Flower should be the president of the fourth Congress, and that this should be held in England, the president-elect to agree with his English colleagues upon the place of meeting.

After speeches from MM. Milne-Edwards, Studer, Sélys-Longchamps and Flower, expressing the high appreciation felt by all the members for the admirably successful labors of the Dutch committees and the remarkable character of the work laid before the Congress, the president declared the sessions of the Third International Zoölogical Congress to be closed.

RELATIONS OF THE WEATHER BUREAU TO THE SCIENCE AND INDUSTRY OF THE COUNTRY.

Mr. President and members of the American Association for the Advancement of Science:

It is a matter of much pleasure to me that I am allowed the privilege of speaking at a joint session of this Association—representing as it does within the confines of its admirable organization the scientific thought of our country. This is the Mecca towards which annually journey all those who wish, each to contribute his mite to the sum of human knowledge; each inspired with an ambition to add even one flickering ray to the great luminous orb which to-day is shedding the benign light of wisdom even unto the uttermost recesses of the earth; subduing the barbarous instincts of man and warming and invigorating into life the better impulses of his nature. Thus is civilization advanced, and thus is humanity elevated to higher and higher planes of existence.

I hope to be a worker in the ranks of this great army, and as the science of meteorology can hardly be said to have passed beyond the embryonic state, I feel that the realms of investigation are boundless, and that the opportunities are correspondingly great.

As the Chief of the greatest meteorological system in the world, and with the power to control, under the direction of the Honorable Secretary of Agriculture, not only its executive functions, but the lines of future scientific investigation, I fully realize the great responsibility that rests upon me, and that, at the bar of public and scientific opinion, I shall, in the years to come, justly be held to a strict accountability for my stewardship.

Before considering the lines of investigation which can consistently be prosecuted by the Weather Bureau, it will be well to note the law which prescribes the duties of the chief.

By an Act Congress approved October 1, 1890, Sec. 3, Statutes at large, Fifty-first Congress, p. 653, it is provided:

"That the Chief of the Weather Bureau, under the direction of the Secretary of Agriculture, on and after July 1, 1891, shall have charge of the forecasting of weather, the issue of storm warnings, the display of weather and flood signals for the benefit of agriculture, commerce and navigation, the gauging and reporting of rivers, the maintenance and operation of sea-coast telegraph lines and the collection and transmission of marine intelligence for the benefit of commerce and navigation, the reporting of temperature and rainfall conditions

for the cotton interests, the display of frost and cold wave signals, the distribution of meteorological information in the interests of agriculture and commerce and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or as are essential for the proper execution of the foregoing duties."

It will be seen that the main object for the existence and continuation of this Bureau is to give warning of the approach of storms, and therefore that the proper line of investigation should be for the purpose of determining the true philosophy of storms. The goal to be striven for is the improvement of weather forecasts, and surely one of the prerequisites to determine coming events is a thorough knowledge of existing conditions.

To those who have read every important treatise on meteorology, and who have studied every text-book on the subject, it is painfully patent that we are extremely ignorant of the mechanism of storms; of the operations of those vast and subtle forces in free air which give inception to the storm and which supply the energy necessary to accelerate cyclonic action when formed, or to disperse the same when once fully in operation. We know that great atmospheric swirls in the shape of high and low pressure areas alternately drift across the country at intervals of two or three days; that the atmosphere flows spirally into the cyclonic or low-pressure system and outward from the anti-cyclonic or high-pressure system, that the in-drawn east and south winds on the front of the storm are warm, and that the inwardly-flowing north and west winds are cold.

The theories of Redfield, Espy, Loomis, Ferrel and others, teach that our great storms are composed of immense masses of air gyrating about a vertical or nearly vertical axis, drifting eastward and at the same time drawing in warm easterly currents at the front and cold westerly currents at the rear; that the commingling of these two as they rise to greater and greater elevations, near the regions of the cyclonic center, throws down volumes of rain or snow; that as precipitation occurs with the ascending currents, the heat of condensation energizes the cyclonic circulation; that the air at the center of the storm is relatively warm, is rarefied by centrifugal force and by reason of less density, rises to a great elevation, and in the upper regions of the atmosphere flows away laterally to assist in building up high-pressure areas on either side.

The high and low-pressure areas are supposed to be carried eastward by the general easterly drift of the atmosphere in the middle latitudes, somewhat as eddies are carried along by water in a running stream.

But, unfortunately for the complete accuracy of these theories, the forecaster often finds heavy down-pours of rain without any cyclonic circulation, and no convectional system in operation; again over immense areas of country, especially in the Rocky Mountain region, for many months in the year condensation occurs not at all in the warmer easterly currents flowing into the storm center, but almost exclusively in the westerly portion of the storm area, where the cold north and west winds are flowing in.

Again, many investigators to-day have good reason to doubt that the center of the storm is warm to any great elevation or that cyclonic circulation obtains to the top of the air.

In outlining, in a rough and general way, the line of investigation which in my judgment promises to give the most prolific results, not only to the cause of meteorological science, but to the making of more accurate forecasts for the benefit of agriculture and commerce, I will say that we have been for

years taking our measurements at the bottom of this great ocean of air, while the forces which cause the formation of storms, and which influence their intensity and direction of motion, operate at great elevations, or are extraneous to our earth. It therefore seems imperative that systematic exploration should be made of the upper air. Balloon ascensions should be made in the several quadrants of the cyclonic storm and also at the center thereof, especially when rain is falling and the barometric gradient is steep. It is especially important to know the level at which condensation ceases, the depth of the cloud stratum, the temperature gradient, the air pressure and humidity, to a height of four or five miles. Skilled aëronauts with complete and accurate instruments should be placed in the region of severest action at the season of the year when storms are most frequent. They should be held in readiness until the approach of storms typical of cyclonic action, and then from the central office, where the movement of the storm is being carefully watched on the daily synoptic chart, they should be given telegraphic orders to ascend, and their ascensions should be so timed as to secure accurate readings at great elevations throughout the several quarters of the storm. It is believed that information thus secured will establish something like an approach to the true philosophy of storms in contradistinction to the very imperfect theories which too often are hastily approved as demonstrated principles. Instead of erecting a cumbersome superstructure upon the sand, let us endeavor to lay a corner stone upon which to erect something exact enough to be called a science.

In winter the great high-pressure areas which constitute our cold waves should receive the same thorough exploration. Readings at Pike's Peak or Mt. Rainier might be useful in this investigation, but they are too far removed from the general track of storms and cold waves to furnish the full information desired.

Upper-air explorations may be accomplished by a train of kites carrying automatic instruments, by captive kite-balloons which may be forced nearer and nearer the zenith with increasing wind velocity, or by the ascension of trained observers in free balloons. We must strive for the perfection of appliances and instruments which will, at no distant day, enable us to present to the forecaster the charted synchronous meteorological conditions prevailing at high levels and covering a great area. Mr. McAdie, at Washington, has secured recently some good records with kites at elevations of from 1000 to 2000 feet.

Systematic exploration of the upper air, with a continuation of the studies begun by Professor Bigelow of terrestrial magnetic forces as induced by the solar magnetic field, will be the line of investigation prosecuted during the next two years, and from which it is hoped that results satisfactory to the practical as well as the theoretical man may be obtained.

The Honorable Secretary of Agriculture is in thorough sympathy with all lines of research which can be legally carried on under the Act of Congress constituting the Weather Bureau, and which promise to give results useful to the people.

Harmonious coöperation between the practical worker and the scientific investigator is essential to success. Too often they have found themselves picking out diverging paths. In the future they will work on parallel and converging lines and not far removed from each other, and the result, I am confident, will be beneficial to all. In a great system like ours each worker must be justly recognized for the merit that is in him, whether he be a skilled scientist or an able executive officer, and he should be given his proper place as an in-

tegral part of the great whole which constitutes the efficient Bureau.

A brief retrospect of the forecast work may not be without compensating results in our efforts at future improvements.

Forecasts were begun in the United States about 25 years ago, and have, during the past decade, become of such benefit to the many and diversified interests of the country that with one accord the people now acknowledge their value and applaud all efforts to improve and extend their usefulness. Fifty million dollars is a low estimate of the value of property placed in jeopardy by one West Indian hurricane sweeping up our Atlantic coast.

Predictions were first called 'Probabilities' and were made for districts, each comprising several States, and included a prediction as to the probable change in barometer. Later the prediction as to barometer was omitted. Forecasting by districts was soon shown not to be specific enough as to boundary, and the designations applied were not well understood by the people; hence forecasting by States was adopted.

Forecasts were made only at the Central Office at Washington, and the local observers were allowed to disseminate no other, nor to give public expression to any opinion of their own which might be construed into a forecast. Considering the very limited training of the observers and the lack of all charted meteorological conditions for their study and enlightenment, the wisdom of that regulation could hardly be questioned.

With the transfer of the Weather Bureau to the Department of Agriculture came the inauguration of far more liberal and progressive ideas. The office of Local Forecast Official was created for such observers as had shown special fitness for forecast work, and they were assigned to duty at the more important agricultural, commercial or maritime centers, with instructions to carefully study the local climatology of their sections, so that products that are indigenous to limited areas, or interests which are of special importance to particular sections, might have such application of the weather forecasts as the intimate personal attentions of a competent local official could give.

The changes enumerated have been carefully tested and found to be beneficent in purpose and worthy of continued and permanent application. Thus has the forecasting system of to-day slowly developed during the past 25 years. Is it not the essential feature of the Weather Bureau? Is it not the nucleus around which all departments of thought and study must rotate and become auxiliary, if the original intent of Congress made manifest by the establishment of a National storm-warning system is to be carried foward to as successful an operation as the present knowledge of the physics of the air will permit? It is hoped that discoveries may be made relative to the controlling and modifying forces of storms which shall raise the standard of forecasting accuracy attained by our most expert officials, who have had all the benefits to be derived from many years of patient and intelligent observation of storms, from the time of their inception in, or entrance within our daily observed and charted territory, until they have been dissipated or have passed eastward beyond our range of vision.

It may be well to consider what class of forecasts can be most successfully made by our more or less empirical methods, the object being to extend the work along such lines of activity as promise the most beneficial results.

As to this proposition it is doubtless conceded by all that when pronounced high and low-pressure areas dominate the weather conditions and the changes in wind, temperature and weather are charac-

terized by such force and degree as to render them destructive to lives and property, a forecaster of average ability and well-balanced judgment is able to make nearly or quite as accurate a forecast as when the air pressure is quite uniformly distributed and all changes of weather are so slight as to be of no importance.

If, then, a destructive frost or cold wave can be predicted as easily as a change of a few degrees in temperature, and if the coming of high winds and gales are as easily foretold as that of a gentle zephyr, it is evident which class of forecasts should receive the greater attention. The public care comparatively little for predictions of moderate changes, and but little credit attaches to the Bureau when such forecasts are verified, but when great heat, cold waves or violent winds are on the programme, a vital interest is felt in the subject, and the accurate forecasting of such conditions is the gauge by which the public measures the usefulness of the Bureau.

Horticulturists and the growers of tobacco and cranberries realize the vast benefit to be derived from accurate frost predictions, and I will give a brief statement of what I believe to be original ideas introduced into the making of frost forecasts while in charge of the State Weather Service of Wisconsin, a State including within its domain the largest area of cranberry marshes in the world, and also including an extensive area devoted to the cultivation of tobacco. Heretofore I believe that only the air conditions have been taken into consideration in the making of frost forecasts—such as pressure, temperature, relative humidity, cloudiness and wind velocity. As a result of my investigations systematically prosecuted for three years I found that the conditions of the soil were equally as important as those of the air.

When the high-pressure area is moving in from the west, clear and colder weather anticipated, with the probability that the early morning temperature will permit the formation of frost, the most important elements to be considered, in determining whether or not frost will occur injurious to growing crops, are as follows:

First: Has rain recently fallen, and what is the condition of the soil relative to the amount of moisture contained?

Second: What are the natural properties of the soil relative to the slow or rapid loss of heat by radiation?

Third: To what degree of heat has vegetation been subjected during the period immediately preceding?

The early fall frost injurious to tender crops occurs with the observed town or telegraphic minimum temperature ranging from 40 to 50 degrees, because, when the early morning temperature in the town falls much lower than 40 degrees, it is usually so late in the season that all crops are gathered, or if not gathered they have been destroyed ere this condition arrives. At the time then that frost warnings are of most benefit we have to deal with the air at temperatures considerably above the freezing point, and to recall that a deposition of frost requires that the temperature of the top soil, or that of vegetation, be reduced to the freezing point. This, of course, is accomplished by conduction and radiation of heat which takes place more rapidly from the soil and vegetation than it does from the lower stratum of air to the higher.

Anything that will seriously interfere with a rapid loss of heat after nightfall will tend to prevent the formation of frost. Moisture does this, and if the soil be well charged it partakes greatly of the stabilty of water as to temperature, and cools but little, if any, below the temperature of the superincumbent air, and no frost will occur even though all other favorable conditions of clearness, gentle winds and cool air obtain.

Even a small amount of moisture, say one-half inch of rainfall, will give ample protection if well distributed and precipitated within the 24 hours previous. But when severe drouth conditions are prevalent, injurious frosts may occur when the telegraphic temperatures do not show a reading within ten degrees as low as in the first case.

I believe that when estimating the probability or severity of frost sufficient weight has not been given to the dryness or wetness of the soil and the resultant dissipation or conservation of heat, and I call special attention to the point as one of the means for improving the forecast.

I have in mind two typical cases. In the first a high-pressure area attended by clear and cool weather drifted from the westward until it covered the State. No rain had fallen with the passage of the low-pressure area immediately preceding it; hence the ground was in excellent condition for the rapid loss of heat during the night, and a consequent lowering of the temperature of vegetation to the freezing point. Considerable damage was done to cranberries in unflooded marshes. In the second case a high-pressure area of slightly greater weight and slightly lower temperature covered the region about ten days later, but it was preceded within a few hours by a light but well distributed fall of rain, averaging about one-half an inch, and no frost occurred. In both cases the wind was gentle from the northwest, and the nights were clear. With slightly lower air temperature and higher barometer in the second condition, heavier frost would have occurred than in the preceding case had it not been for the thinly spread moisture of the timely rain conserving heat at the surface of the earth.

Might not this principle be carried further in the improvement of the forecast? Assuming that the caloric energy of the sun is a constant factor, the earth receives each year the same amount or intensity of heat, and as the atmosphere is warmed mainly by contact with or radiation from the earth, seasonal variations of temperature which are marked departures from the normal might result from abnormal terrestrial surface conditions with respect to the conservation of this constant solar energy over large continental areas. Here the excessive or deficient rainfall during the preceding seasons should receive careful consideration. The subject is one that requires deeper and more detailed investigation than the length of this paper will permit.

I find that the minimum temperatures in cranberry marshes during abnormally dry seasons often fall 15 degrees below the temperatures telegraphed from the cities and towns within a few miles of the marshes. This is due to the fact that when the loose, spongy peat, of which the marsh is composed to the depth of several feet, has dried out, the radiation of heat during the night is very rapid and is not counterbalanced by conduction and connection from the marsh. The temperature, therefore, in cranberry marshes is at all times much lower than that which obtains in marshes composed of heavy black muck, where it preserves a more equable condition, such as is common to air resting over a considerable body of water. A dry cranberry marsh does not, therefore, enjoy that immunity from frost which wet marshes and watery lands get the benefit of. But when the ditches are flooded from the reserve water supply on receipt of a frost warning, the water quickly percolates through the peat composing the marsh, and the rapid loss of heat by radiation is checked and the frost averted.

The degree of heat to which vegetation has been subjected immediately before the frost condition, and the temperature under which it had made its growth, will in a great measure determine the extent of damage to ensue.

By carefully considering the principles herein enunciated, I will say that in 1894 12 out of 14 official forecasts of frost were fully verified—a much greater percentage of accuracy than has ever been attained by simply considering air conditions alone.

Willis L. Moore,
Chief of U. S. Weather Bureau.

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*SALIX WARDI, BEBB.**

It is desirable to know much more of the range and specific place of this very interesting willow than is yet known. Having visited it the past season in its native habitat during flowering time, May 10th, at Bonneterre, Mo., and again when in mature leaf at Pilot Knob and Irondale, Mo., August 19th–20th, also at Washington, D. C., June 18th, I felt, though not without considerable diffidence, that my observations might prove of interest.

If my observations, in some respects, clash with those of our eminent and acute Mr. Bebb, the fact should be ascribed to variation of, or probably to more complete material.

The S. Wardi extends northward to within about 37 miles of St. Louis in greater or less abundance, intermingled with S. nigra and S. longifolia. One, and but one, I discovered growing on the banks of a lake in the Mississippi bottoms, about 8 miles northeast of St. Louis. Hybrids between the Wardi and nigra occur, but are not common, as is the case with nigra and amygdaloides.†

Though without question specifically distinct from nigra, and seeing it in growth, never to be mistaken for nigra, yet it presents several important characters reminding one, again and again, of the latter. Such are the general shape of the leaves, short petiole, persistent stipules, the staminate aments, number of stamens, scales, capsules, but especially the almost absolute correspondence of venation, also the extension of the flowering laterals beyond the base of the rachis, is but the same character often observed in nigra emphasized. And yet further, the bark, though distinct, has a resemblance to that of the young stems of nigra. Still another reminder of the relationship is the near likeness of discoloration of dried specimens, as well as the color and taste of their infusions.

The following will embrace my observations of its main features: Salix Wardi is either a shrub or tree, usually the latter, which rises to the height of 10–15 feet, or exceptionally to 20 feet, 2 to 7 inches in diameter, spreading top, scraggy branches, tending to curve downwards; twigs tenacious, even as to bases, tips winter-killed; bark of stem and main branches are dark grey or blackish (therefore by the natives called 'black willow'), deeply latticed-ridged, resembling that of a youngish black walnut, intensified; it is lichen-covered on its northern aspect. The stem usually stands single, not in clumps as is common with S. nigra. The leaves vary from long narrow, to shorter oblong or ovate-lanceolate, matching fairly well, in their range, the forms of both nigra and amygdaloides, whitish glaucous beneath, pubescent when young, with short petioles; the bases of the leaves range from acute to auriculate, or cordate; stipules large, persistent, variable, roundish, irregular reniform, rhomboidal, oblong, the upper half often serrate, *glandless*, all obtuse; any tendency of pointing appearing to indicate contamination from nigra; young shoots very leafy, rather heavy, intensely whitish hoary pubescent (mostly); aments long, on many leaved laterals which are prolonged beyond the origin of the rachis; capsules smooth, ovate, ovate-conical, globose-ovate, with firm walls retaining shape in drying, line of suture conspicuously marked, slow to open; style and stigma exceptionally undeveloped, the

* Garden and Forest, Vol. 8, p. 363.

† See writer's 'Relations of Nigra, etc.,' Vol. 6, No. 13, Acad. Sci., St. Louis, Mo.