

It is necessary to cite only her manufactures involving high temperatures, such as the porcelain industry, to appreciate the help afforded by the Reichsanstalt. The methods and instruments elaborated there for the exact measurement of high temperatures constitute a splendid contribution toward industrial supremacy in those lines. The German government sees with great clearness that the Reichsanstalt justifies the expenditure made for its maintenance, not by the fees received for certifications and calibrations, but by the support it gives to the higher industries requiring the application of the greatest intelligence. In this connection it should be thankfully acknowledged that the services of this imperial establishment are placed at the disposal of foreign institutions of learning with the most generous liberality. The charges for calibration are only about one-fourth the expense incurred in making them, but the support thus given to German makers of instruments of precision, by increasing their foreign orders, is deemed a sufficient return for the services rendered.

HENRY S. CARHART.

UNIVERSITY OF MICHIGAN.

PLANT GEOGRAPHY OF NORTH AMERICA.

I.

THE PHYSIOGRAPHIC ECOLOGY OF NORTHERN MICHIGAN.

I. *The Physiographic Standpoint in Ecology.*—Warming's classification of plant formations, doubtless the best we have, is inadequate to explain many of the facts that are brought out in field study. While water is certainly the most important single ecological factor, it cannot be made the only standard for classification; the difference between the flora of drained and undrained swamps is not a question of water content, but probably of drainage; a heath and a moor have similar ecological adaptations, but are very diverse as to water con-

tent. A classification to be correct must also be dynamic and must present the flora of a district from the standpoint of its past and future, thus dealing with genetic relationships. A classification which runs parallel with the normal physiographic changes in a region meets all these needs and presents the flora as a unit, taking account of all the interrelations. The various ecological groups or plant formations are presented in a historical sequence, ending in a normal climax or culminating type, corresponding to the base level of physiography.

II. *Application of the Physiographic Standpoint to Northern Michigan.*—A. Progressive Development of Plant Formations. The vast majority of natural formations are developing toward the climax type, which for Northern Michigan is a mixed forest in which the hemlock, beech and sugar maple dominate. At the outset the conditions may be xerophytic or hydrophytic (using these terms in the original sense as referring to the water content of the soil).

1. Xerophytic to Mesophytic. In a young region, xerophytic formations are found commonly on hills and along exposed shores. The development on the hills is widely variant; perhaps the climax condition is first reached on clay hills, because of the ease with which water is held and humus formed. Sand hills reach mesophytic conditions relatively late, because they possess opposite physical characters. Rock hills commonly have a slow development because disintegration and soil formation are first necessary; a lichen vegetation first appears, then a crevice vegetation, finally other stages, closing with the mesophytic forest. Rock hills of course vary greatly among themselves, the development being almost inconceivably slower on granite or quartzite than on limestone or shale. Xerophytic shores are much more uniform, having first an annual, then a perennial vegetation, and finally the several forest

types in succession; often a dune phase is interposed in this series, immediately after the beach.

2. *Hydrophytic to Mesophytic.* Hydrophytic areas are common in young regions and are either drained or undrained. Undrained lakes and swamps are very common at first, but are very rapidly filled by vegetation, so that one formation rapidly follows another from the lake to the forest; zonal arrangement is usually found in these places. Drained swamps and rivers often increase as a region grows older; progressive development is best seen on the flood plains, where the order of succession is commonly well marked and rapid, culminating in the very highest type of mesophytic forest. There are often hydrophytic shores along the lakes, usually in the less exposed places; their history is much like that of a swamp.

B. *Retrogressive Development of Plant Formations.* Retrogression is commonly local or evanescent. It is best seen along lake or river bluffs, where constant erosion causes the destruction of mesophytic formations. When erosion ceases, progressive movements begin, culminating again in mesophytic floras. Retrogressive movements may also be caused by crustal movements, changes in climate, or through the action of man.

HENRY C. COWLES.

UNIVERSITY OF CHICAGO.

II.

THE RELATIONS OF THE NORTH AMERICAN FLORA TO THAT OF SOUTH AMERICA.

IN my paper on 'The Relation of the Flora of the Lower Sonoran Zone in North America to the Arid Zones of Chile and Argentine,' attention was called especially to discussions by Gray and Hooker and by Engler on the presence of North American or boreal floral elements in South America. The species considered in the two citations were chiefly alpine and mountain xerophil-

ous plants of the Rocky Mountain Region and the arid Southwest (the latter especially by Engler) which occur in the Mexican Cordilleras and in the boreal altitudes of the tropical Andes, becoming more generally distributed in the extra-tropical Andes and the higher plains of Chile and Argentine. My own paper attempted to show that a very significant number of the genera representing the most extremely xerophilous elements of the enclosed desert plateaus and valleys of the Lower Sonoran Zone, reappear in correspondingly arid regions far south of the equator, and that the intervening territory contains these rarely or not at all. It further discussed the problems of distribution between the two regions, going in some detail into a discussion of certain species which illustrate the case especially well.

In this paper the purpose will be to point out the generally known and accepted facts of relationship between the floras of North and South America as illustrated in all the floral elements represented in both, emphasizing more particularly the elements which I have studied in some detail which furnish additional evidence for conclusions already suggested rather than offer a new solution to the more difficult problems of distribution.

It may be said as an elementary observation, that if we consider only the present aspects of plant life, and conceive the floral zones of North and South America to be due to and lie coincident with zones of latitude, we should have in the two Americas only the tropical zone in common, shading off into the north and south zones of lower temperature, in which the likelihood of a mixture of boreal and austral elements of any two corresponding boreal or austral zones would grow less with increasing proximity to the poles. The question of distribution would be chiefly one of distance which might or might not be overcome by