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The mapping of plant associations

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Professor Penck subsequently showed a number of excellent Geographical Wall Pictures, the use of which he advocated for the teaching of geography; and the work of the Section was brought to a close by an address from Professor W. M. Davis advocating that Geography should be made a University subject.

The Toronto meeting has been a most successful one, and the value and interest of the papers read in the Geographical Section have rarely been exceeded.

Crowded evening meetings were addressed on Friday by Professor Roberts-Austen on "Canada's Metals," and on Monday by Professor Milne on "Earthquakes and Volcanoes."

In addition to work in the meeting-room, a most attractive programme of excursions was organised by the Local Committee, including visits to Niagara, the Muskoka region, Parry Sound, Ottawa, Kingston, Montreal, Algonquin Park, and other places. A special excursion to Vancouver left Toronto in four detachments shortly after the final meeting of the Association. Numerous garden parties, given by hospitable Canadians, occupied the afternoons. Their Excellencies the Governor-General and Lady Aberdeen gave a reception to which all members and associates were invited; a banquet was given in honour of Lord Kelvin, Lord Lister, and Sir John Evans, and altogether the time passed at Toronto was extremely busy, delightful, and profitable.

THE MAPPING OF PLANT ASSOCIATIONS.

By ANDREW J. HERBERTSON, F.R.S.E., F.R.G.S.

EVERYBODY who has studied maps of plant distribution finds, as a rule, nothing but a series of lines marking the limits, usually of many species of different orders, crossing and recrossing each other in almost inextricable confusion. Even in the admirable compendium of botanical topography, Dr. Drude's *Pflanzenverbreitung* in Berghaus' Atlas, some of the maps are rendered almost undecipherable without a magnifying glass and much patience, owing to the amount of detail crammed into them. For the geographer something more is needed. He does not want the exact limits of every species of living plant charted, any more than he desires maps for every species of fossil; he requires maps of botanical associations just as he has at his service maps of geological formations.

The geological map is a synthetic chart conveying an immense amount of information to the trained reader—each different formation telling of different structure and different fossils bespeaking different conditions of origin. The botanical map should do the same—to the student it should indicate different floral types, depending on different physical conditions.

How are we to distinguish the different floral associations?

In the floral associations it is just as essential to find out what are

the typical and non-typical species as it is necessary to distinguish between the characteristic and non-characteristic fossils in the different geological formations. This is a work involving no little research as well as much discrimination.

The results of the geologists' investigations carried out in this way have proved of immense service to the geographer, especially in his study of the physical configuration of the earth; and there is every reason to believe that similar work carried out by competent botanists for plant-life will be of equally great value to the geographer, more particularly to the student of economic geography.

The practical value of such floral maps can hardly be exaggerated. Wherever man wishes to cultivate the ground a study of its actual flora is the most reliable guide to the possibilities of success or failure of new species. Each natural floral area has its special diathesis, and only plants whose diatheses are analogous can flourish in these areas. How much waste of money and time might have been saved to settlers in most of our colonies if a systematic floral survey had been made; and how much might still be saved by doing this!

It may be urged that climatic maps would do as well, as climate is one of the chief determinants of plant distribution. But climatic data are too scanty for this purpose; and little beyond very general deductions can be made from the ordinary climate maps. For the small-scale maps of an ordinary atlas the climatic data may suffice. For a map of 1 : 1,000,000, even of Scotland, the number of meteorological stations is quite inadequate, especially in the hilly parts of the country where they are most needed. If the climatic conditions of this country are so imperfectly known from the botanist's point of view, how much more is this the case in many of our colonies where meteorological observations, except at a few coastal towns, have been begun only within the past few years.

But in the flora of a region we have a climate guide, difficult to read at first, because we lack the meteorological data to correlate climate and flora, and because the influence of the soil and drainage is a very important factor in plant distribution. Although this factor embarrasses the theoretical climatologist, it is one which the agriculturalist must necessarily take into consideration; and to him, therefore, the characteristics of floral areas are better guides than those of climate alone.

In our own country the study of the distribution of plant associations is a necessary preliminary to the successful working out of the pressing problems of reforestation. In some parts of our colonies and of the United States the question of replanting the forests, that have been or are being recklessly destroyed, is also an urgent one. The study of plant associations is of even greater consequence in the unoccupied or only partially occupied regions of the globe, as a knowledge of their nature and distribution would prevent many costly experiments doomed to be failures. The colonies find it pays to spend much money on mineralogical surveys and maps. They would find it even more satisfactory to do the same for plant associations. Then good farmers would be readier to settle in new regions, and those with money to invest would not hesitate

so much to help colonial agricultural enterprises which could show reasonable prospects of success.

One of the duties of all agricultural stations should be the discovery of the cultivated plants that can be successfully grown in the regions of different natural floral associations. Experiments with such cultivated plants can then be carried on in the regions of the favourable floral associations with some hope of success.

The criteria distinguishing one floral association from another must be settled by experts in plant distribution, as those for geological formations have been by geologists. They can be settled only by practical study in the field, where all the conditions of their life can be observed at the same time, for neither botanical nor geological distributions can be studied merely from herbarium or museum collections, indispensable as these are to botanist or geologist.

There are many difficulties to be overcome. The choice of typical species is not an easy one, and the tracing of their distribution is a difficult task. For instance, in a settled region the cultures of men have masked their natural distribution, and often a close study of a region reveals the fact that it would have been better for man had they not done so. Again, one side of a valley may belong to one association and the other to another, and if the valley curves acutely these may be interchanged, and mapping becomes very complicated.

Suppose the botanist has determined the characteristics of the chief botanical associations, the geographer is eager to learn how the limits of each are to be traced and their distribution mapped. There is then the further question of the notation to be adopted on the maps. The mapping should clearly indicate the boundaries of the floral areas and permit the ready comparison of the botanical map with those of other natural conditions, so that all may be correlated and interpreted.

We therefore welcome the paper by Professor Flahault of Montpellier in the July number (1897) of the *Annales de Géographie*, called *Essai d'une carte botanique et forestière de la France*, as one of the most important of recent contributions to botanical geography. Professor Flahault is known among botanists as one of the most learned and able of their number; and every botanical paper he produces is characterised by minute observation, clear comprehension, masterly interpretation, and lucid exposition. Of his special fitness to undertake the work of distinguishing between the different floral associations in France there can be no question. The discussion in detail of this part of his work must be left to botanical experts in their journals. Here we have to do with Professor Flahault as a geographer.

As a botanical geographer, Dr. Flahault has travelled from the far north in Sweden to the Sahara in Algeria, while for the purposes of his botanical survey of France he has walked many thousand miles, and mapped the limits of the different plant associations on the 1: 80,000 map. The area surveyed in this way, during the last few years, is over 120,000 square kilometres (45,000 square miles), and, indeed, every minute that could be spared from professional duties at Montpellier has been spent in this work since it was first undertaken.

As a sample of his methods and results, Professor Flahault has published one of the thirteen sheets, now ready, on a scale of 1 : 200,000. This sheet, the floral map of the Perpignan region, has been chosen as perhaps the most complicated of any, for it embraces five great natural regions. First, the littoral flora—the salt-loving plants that flourish along the coast of the Mediterranean. Second, the evergreen flora of the Mediterranean, with the evergreen oak (*Quercus ilex*) as a typical species, mixed with the cork oak (*Q. suber*) in Roussillon and the Narbonnaise. Third, the deciduous forests of temperate regions, willows and poplars forming the river woods, *Phragmites* and *Alismaceæ* in the lagoons, marshes, and irrigated meadows of the plain, and with the oak (*Q. sessiliflora*) on the plains, and also on the lower hills, where the chestnut grows (*Castanea vesca*); while on the slopes of the Pyrenees these are replaced by the beech (*Fagus sylvatica*) and spruce (*Abies pectinata*). The fourth natural region is the sub-Alpine area of resinous trees, such as the Scots fir (*Pinus sylvestris*) and the mountain pine (*P. uncinata*); and higher up the mountains, above 2000 to 2300 mètres, is a fifth area of continuous pasture, the Alpine region of gentians, *Swertia perennis*, and *Saxifraga oppositifolia*.

Professor Flahault gives a brief account of these associations of plants and the conditions in which they are found, reserving details for the botanical memoirs.

A very beautiful map, which is the most important part of the communication, shows the distribution of twelve typical associations. The region where the maritime pine (*Pinus pinaster*) grows is distinguished from the rest of the littoral region; the Mediterranean region is illustrated by the distribution of the evergreen and cork oaks and the *Pinus laricio*; the Temperate Forests by oak, chestnut, beech, and spruce, while the Scots and mountain pines represent the sub-Alpine associations.

Professor Flahault asks for criticisms on the map. For the geographer, the guiding principle in making such a map should be to emphasise the primary natural areas, and to show the subdivisions of these areas in a less obvious, yet still distinct, manner. The best way to accomplish this is to choose a different colour for each great area, and to use various tints and shades of it to bring out the minor areas. For ease in interpretation the sequence of colours chosen should be that in the spectrum. In the case of vegetation maps, warm reds should be selected for the floras of hot regions, and cold blues and violets for sub-Alpine, Alpine, sub-Arctic, and Arctic floras. Such a scheme of colouring affords a graphic guide, not merely to the distribution of floral areas, but, at the same time, to the great climatic regions.

To a certain extent Professor Flahault has adopted this order of colours in his map, but he has allowed the botanist to get the better of the geographer, for he has emphasised too much the different associations composing each natural floral region, and consequently these five great regions do not stand out so distinctly on the map of the Perpignan region as they should have done. The botanist, too, is responsible for tinting the distribution of all pines, whether the maritime or mountain species, in shades of blue. The attempt to give a certain uniformity to the con-

ferous areas might have been successfully accomplished by simply using a slight cross ruling of blue over the special colour of the great natural regions, which was not strong enough to annihilate the ground colour. In the case of the sub-Alpine region, where Scots and mountain pine both occur, this could also be done for one species, or a stipple of blue used for one species and solid blue for the other.

The map is open to criticism in the regions where two of the typical species are found. The device adopted is to show such regions by parallel bands alternately coloured by the tints of the one and of the other species. This is certainly preferable to introducing coloured lines tracing the limits of one species and colouring the whole area the tint of the other species. It is, however, hardly satisfactory on such a large-scale map, although on a smaller scale it is the only alternative. As it often happens that one species is found on one side of a valley and the other species on the other, it should have been quite possible to illustrate this in many cases on the 1 : 200,000 map. Where this was not possible, or where there was an actual mixing of the species, the tint of the predominant one might have formed the solid colour, while dots might have shown the distribution of the other species, the dots varying in closeness, and perhaps also in size, with the abundance of the second species. Such a device is at once more graphic and accurate than the one adopted, even where the thickness of the band is made proportional to the relative abundance of the species it represents, which always conveys a confused impression, and should be used only when the other is quite impracticable.

On such a map, too, with the colours for the five great natural regions quite distinct, more detail might have been shown within each region. This is true more particularly of the plain. It is a pity that the actually cultivated areas were not shown (by using a lighter or darker impression—stipple instead of solid, or *vice versa*). Although this might not increase the scientific value of the map, it would not have impaired it, when carried out in the manner here suggested, and it would have added greatly to its economic and historic value. The essential matter, however, in such a map is that the general be obvious at a glance. A limit must be set to details as soon as they begin to interfere with the clearness of the representation of the great natural areas.

Similar work should be done in the British Isles where questions of reforestation and of changes in agricultural products are of immense importance at the present day. Mr. Robert Smith, B.Sc., Demonstrator in Botany, University College, Dundee, a pupil of Professor Flahault, has begun to map the floral associations of Scotland, and has two or three sheets nearly ready; but the practical urgency and value of the work demands, not merely the spare moments of an individual worker, but rather the united efforts of the staff of a national survey.