The Value of Regional Geography.

(*Herbertson Memorial Lecture*, 1921).

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THOUGH I can say little that is new, I can repeat, with some modifications due to growing experience, a few of the truths which made life worth living to the geographers who founded this Association.

There have been many periods of revival in geography, e.g., in the period of Cook's voyages, the period of the foundation of the Royal Geographical Society in 1830, and that of the last decade of the Victorian era. I ask you now to look back just as far into the nineteenth century as you have advanced into the twentieth.

Forty years ago two independent centres of renewed interest in geography were developing in Great Britain, one of these naturally in London, where the Royal Geographical Society, stimulated by your late President, Mr Douglas Freshfield, broke into fresh activity. An early sign of this was the establishment of the " new series" of PROCEEDINGS and SUPPLEMENTARY PAPERS, another the encouragement of geographical teaching in the public schools and elsewhere. It was then that Sir John Scott Keltic began his long connection with geography by a tour of Europe as a commissioner of the Royal Geographical Society to collect information as to teaching on the continent. He brought back a great collection of books, maps and models, the exhibition of which in various places may be taken as the first stirring of the present advance in geographical education. From the London centre the wave was propagated, not without difficulty, to Oxford and Cambridge, and the persuasive oratory and brilliant generalizing of Sir Halford Mackinder soon justified the efforts of the Society, and the character of the southern centre became definitely educational.

Simultaneously another wave was forming in and spreading from Edinburgh, and of this I wish to speak in more detail, for the facts are less familiar. In Edinburgh the results of the CHALLENGER expedition were being worked out at Government expense. The work was under the direction of Sir John Murray, whose masterful personality could no more be bound by red tape than Samson by willow withes. The CHALLENGER office was a pulsing focus of activity for all the Earth sciences, physical as well as biological, and specialists of every kind from every land met there.

At the University of Edinburgh, two masters of Mathematics and Physics, P. G. Tait and George Chrystal, were drawn into the closest association with the CHALLENGER work. With them co-operated Alexander Buchan, the secretary and the life of the Scottish Meteorological Society and the pioneer of distributional meteorology, and John George Bartholomew, just beginning to illuminate cartography with the light of his geographical genius. Sir Archibald Geikie, with his unrivalled eye for geographical form and geological structure and his inspiring pen, was handing over to his no less gifted brother, James Geikie, the Chair of Geology and the affection of his students, while Patrick Geddes was throwing the glamour of his synthetic mind on the application of geographical principles to social conditions.

The ninth edition of the ENCYCLOPÆDIA BRITANNICA, under the brilliant guidance of Robertson Smith, J. S. Black, and H. A. Webster, and CHAMBER'S ENCYCLOPAEDIA, under the inspired editorship of D. Patrick, strained their alphabetic framework to fit in the new results of the CHALLENGER work as each new volume appeared.

From this gathering of kindred minds sprang in the eighties four important scientific developments—the Ben Nevis Observatory for the investigation of the upper air, the Scottish Marine Station for the investigation of the surrounding-waters, the Royal Scottish Geographical Society, and the Outlook Tower and Museum, which, starting as a museum of local geography, became a main factor in the modern town-planning movement.

Research and the applications of research to practical affairs were the aspects in which geography was presented to those students and workers who were caught by its influence, and when the waves from the northern and southern centres met, research and education became common aims to both. It was about the time of that meeting that the GEOGRAPHICAL JOURNAL was established by the Royal Geographical Society, and the Geographical Association had its first humble beginning under the fostering care of Mr B. B. Dickinson and Mr J. S. Masterman.

It is not altogether surprising that following the ancient centrifugal tradition, geographers soon began to pass southward from Edinburgh—G. G. Chisholm to London, J. Y. Buchanan to Cambridge, A. J. Herbertson and H. N. Dickson to Oxford and Reading. It was a time of great ideals, and many of us were stimulated with hopes which now seem extravagant ; but they expressed a driving power and did something. At any rate the recollection of what geography promised then leaves one in the fullest sympathy with the aspirations and the endeavours of the present far more moving upheaval. To me the breakdown of full international co-operation in science means the collapse of a life's efforts ; but to the rising geographers of to-day the new groupings promise an opportunity to be envied. Conditions have changed. If I had not faith in the continuity of the old fundamental principles, I should not be here to offer a tribute to my old friend to-day.

While all the activities were at their height in that now far-off time in Edinburgh, I first met Herbertson, and for a few years we saw a good deal of each other. I remember how useful his help was in working out the calculations of the sea temperature work of the Scottish Marine Station. I recall his interest in the work on Ben Nevis, when he spent some time on the summit of that mountain studying the humidity of the atmosphere. Later he gave a helpful hand in the bathymetrical survey of the English lakes, and on returning from his studies at Freiburg he developed the teaching of Buchan in his important discussion of the monthly rainfall of the land of the whole world. Herbertson's Edinburgh activities culminated in his co-operation with Buchan and Bartholomew in the editorship of the great Atlas of Meteorology, a work which in itself would have made a worthy monument.

At Montpellier, Herbertson had come under the influence of Flahaut, which turned his attention to the mapping of botanical features, so that his early acquaintance with all departments of physical geography was remarkably complete. I think that much of his subsequent success as a teacher, first at Manchester and afterwards at Oxford, was due to this first-hand practical grounding in the fundamentals of geographical science. Nature is only feebly represented even in the best of writings and mapping, and the only effective training for a geographer is to be found in the open—on the sea, the plains and the mountains.

I knew Herbertson best before he went to Oxford, and I remember him as a delightful personality. At once sanguine and serious, he was fired by ambition, but controlled by a modest estimate of his own powers, a man who made friends and attracted students. Circumstances guided him more and more towards education as the field in which he pursued geography, and our paths diverged. His efforts were hampered, as those of all professional geographers in this country have been, by the inadequate financial conditions attached to public offices. If the necessity of supplementing his income gave us the benefit of a series of valuable text-books and renders, I cannot help feeling that it deprived us of the mature results of his early studies and researches. This is the more to be regretted because while a member of the Royal Commission on Canals he had obtained insight into the prartical side of geography as it affects the engineer and business man, a valuable supplement to scientific and academic experience.

There are many here who knew Herbertson as a professor better than I did ; but there is no one who appreciated more fully than I do his high character, his early enthusiasm, and his later success.

I do not think I am wrong in viewing as one of Herbertson's more notable services to geography in this country his insistence on regional study, laying stress on the association of the facts of geography with the diverse conditions of a particular portion of the land surface. There has been a tendency to treat geography from the point of view of world-wide distribution. This is right enough in itself, but becomes wrong when the conception of scale is left out of sight and a partially instructed exponent attempts to apply general facts to particular cases or places. As an example, there is no better established general fact than, the existence of the Brave West Winds of the Roaring Forties. But it is wrong to make the dogmatic generalization that a west wind always blows in those latitudes. One must remember that the sum of phenomena, the average of which yields a general law, is an algebraic sum, so that while one can argue quite accurately from the particular to the general, one cannot do so with the same certainty from the general to the particular. Wise folk veil this irreversible process by talking of " prevailing winds," that is, winds which blow most days, but not every day ; and this illustrates what I have come to recognise as the prevailing weakness of popular exponents of geography and of all other things as well.

I lay stress on the importance of regional geography as the foundation of general geography not because it has always been ignored, but because there is a tendency, especially perhaps amongst teachers, to prefer the discussion of general laws to the classification of demonstrated facts. If we had not in view the clear formulation of general principles embracing and explaining all phenomena, the pursuit of any science would be a soul-less task ; but no general principles are worth formulating unless they are based on clearly established facts. In geography such facts must be established by observation and measurement, and the interaction of mutually dependent facts must be studied for each particular region, before we need look for the unifying principles which will establish a general geography.

A Scheme of Regional Geography.

I shall devote the remainder of this lecture to the consideration of how regional geography may best be studied, and I should perhaps apologise for basing it mainly upon my own experience. Long ago it seemed to me, rightly or wrongly, that many of the wide generalizations common in books of geography depended on a basis of probability rather than of fact, and that this was the case in particular with the theories of the influence of environment on human life. The idea was crystallized when in 1896 the editors of KNOWLEDGE asked me to write an article on Geography in the Victorian period. To mention the Victorian period now is usually the occasion for sneering at a time that is out-of-date and rather ridiculous ; but then it was an excuse for glorying in the almost incredible advances which had carried human knowledge almost to the zenith of historical possibility.

I referred in this article to the great mass of information which had been obtained as to the surface of the British Isles by a multitude of Government departments during a long series of years, but had never been brought together in the form of a geography of the British Isles, which I thought " would form, if properly carried out, the greatest geographical work of the coming century."

The idea was so attractive that later in the same year I submitted an ambitious scheme to the Royal Geographical Society [1] for a complete description of the British Isles based on the one mile to one inch map of the Ordnance Survey, and taking account of the work of the Geological Survey, the Admiralty survey, the Meteorological Office, the Board of Agriculture, the Board of Trade, the census returns, and supplemented in certain directions from special surveys or studies. The suggestion was made to prepare a memoir for each sheet of the map, treating each in a precisely similar way, and ultimately combining and condensing the information into a series of regional memoirs, each treating of a definite geographical unit, and finally condensing and summarising the whole into a single volume dealing on a proportionally reduced scale with the whole United Kingdom. I anticipated important practical applications for such a geographical study, laying stress on the possibilities it would reveal for the utilization of water-power, for afforestation and agricultural development. But I had the intelligence to own that the project was only " a seductive dream."

However, it attracted some attention, and I prepared a sort of estimate of the extent of the work and the time it would take to accomplish, viz., 20 volumes of about 1,000 pp. and twenty years. Had it been undertaken and had the estimates proved accurate, the work would have been almost finished before the war broke out. If that had been so, the total cost could have been saved ten or a hundred times over in the prevention of waste on aerodromes on impossible sites, or attempts to cultivate land unsuited by its nature for agriculture, and by the utilization of water-power to conserve coal ; to mention only a few of the applications to which it might have been put.

The scheme did not go through. In accordance with the wish of the Council of the Royal Geographical Society, a specimen memoir was prepared for Sheets 317 and 332 of the one-inch ordnance survey map, [2] or I should rather say an attempt was made to prepare such a memoir, the success being limited by the impossibility of dealing with an isolated instance without machinery that once provided would have sufficed for turning out a large series on a uniform plan. Thus, although the earlier stages of the work were complete enough to have stood as part of the scheme, the later parts were merely illustrations of how the completed work should shape.

The mathematical and physical aspects were pretty fully dealt with, giving a complete statement of the position, mean altitude, and surface configuration of the land, as these were laid down once for all by the Ordnance and Admiralty surveys. The ideal physical map of a natural region should represent these features and no other no roads, woods, houses, towns, parish or county boundaries, nothing but the naked surface of the land. The only lines permissible on such a map are contours of altitude, stream-lines, watershed lines, and, like the shadow of a fine spider web, the degree net proper to the map projection. To obtain such an ideal physical map from the Ordnance Survey publications means a process of stripping away nearly all the work that makes a map worth anything to the public which uses maps for practical purposes. To understand a district from the point of view of a scientific geographer, this stripping is most useful. From the theoretical point of view the broad outlines of the geology might perhaps come first. The order is arguable. I believe some artists have begun a picture by first painting the skeletons of the people represented, then painting over the bones the nude forms, and finally painting the draperies, which alone are present to the eye in the final picture. Other artists, I believe, omit the skeleton except in so far as its forms are visible in the figure. I am of those geographers who leave to geologists, the anatomists of the Earth, the study of the bones and their articulations, except in so far as these affect the surface or explain its forms. So I would describe the nature of the soil and the order of the rocks after having made a clear picture of the actual configuration of the surface

The next condition to describe is the effect of the atmosphere, and here we pass from static to dynamic geography, from the solid forms of the land to mobile distributions. Here we pass, too, from the definite results of surveys which, save for revision and correction, are complete and final, to conditions which are ever shifting and have been investigated only partially, if at all.

In geography we may take it as an axiom that what cannot be mapped cannot be described, and we must recognise also that if we take a sufficiently small portion of the surface we may find nothing to map. In any six-inch map of uninhabited country there are many square inches of blank paper, between the contour lines where the slopes are very gentle and the surface bare. So although it is easy to draw isobars and isotherms on a map of the British Isles, the data available do not always suffice to do so on a single one-inch sheet, and even if the data were there, the whole sheet might haply fall between two isopleths. Hence a general statement has perforce to take the place of detailed description ; but it is not so with regard to rainfall. Data of 18 years' average rainfall at 27 stations situated in the sheets dealt with were supplied by the British Rainfall Organization, then presided over by its founder, Mr G. J. Symons, and from these a rainfall map was constructed, which I now see to be imperfect in many respects ; but it is quite representative of the type of distribution and served its purpose well.

Next came the problem of the vegetation, and here no maps were available, such as those of plant associations which have been made by various experts for various parts of the country. In the conditions of time and assistance all that could be done was to deal with the agricultural returns, which are only published in total acreage for counties for each year. The Board of Agriculture generously gave access to the parish totals for a particular year, on condition that the figures should be re-grouped in larger areas before publication, as the returns from individual farmers are confidential, and to publish parish figures might enable the curious to guess at the produce of the larger farms. They were grouped according to the main geological characters (here only London clay, chalk, and the lower clays and sandstone) in five groups according as the parishes lay wholly on beds lower than the chalk, wholly on the chalk, wholly on beds higher than the chalk, or partly on chalk and lower beds, or partly on chalk and higher beds. The classification was crude and adapted only for the particular region ; but it would have been very helpful if average results for many years could have been worked out ; still more if groups for different successive periods of equal length could be calculated and compared.

The next step was to deal with population, for which the returns of successive censuses afforded abundant data. An approximate population map was prepared by simply blacking in the areas of towns and villages, as shown on the one-inch sheet, and transfering these to a tracing, on which each isolated dwelling was also shown by a dot. A line was then drawn enclosing the completely uninhabited areas which lay more than quarter of a mile—of course an arbitrary assumption—from the nearest dwelling, general census results for parishes and the Registrar-General's statistics were then discussed.

Mineral resources being of little importance in the district and traffic small, the Board of Trade figures were not made use of. However, a great deal of anthropogeography came in with the discussion of the sites of villages and towns, the roads and railways, and the whole attempt concluded with a complete index of place-names.

I wish to make it clear that the " Fragment of the Geography of England" was only a skeleton of what the complete geographical description aimed at being. The scheme was well received, but came to nothing. It has been taken as a model for exercises in regional description by geographical students. I do not think, however, that this was quite a fair use to make of a plan in which the detailed description was only a first step.

The difficulties in the way of carrying out the original scheme were far greater than were suspected when it was proposed ; but experience suggests that ignorance of the difficulties ahead is a help rather than a hindrance to the formulation of any new enterprise. As a rule difficulties can be met and dealt with as they arise, even if their magnitude has not been foreseen.

The Rainfall Map.

Circumstances led me to the opportunity of working at one small part of the great plan, namely, the relation of rainfall to configuration of the land, and perhaps the best service I can render to students is to show, if I can, the real nature of this very simple problem in geography.

I view geography as the science which deals with the forms of relief of the Earth's surface, and with the influence which these forms exercise on the distribution of all other phenomena, or, less precisely, as the influence of configuration on mobile distributions.

The particular case in hand is the influence of the configuration of the British Isles on average annual rainfall. The Ordnance Survey supplied all necessary facts as to configuration expressed in the continuous flowing contour lines which generalize the results of all levelling operations, thus furnishing the basis for the rainfall map.

Some experiments in mapping the rainfall of individual very wet days contradicted the facile assumption that surface relief controlled the distribution of such falls. On a wet day the wettest places were sometimes on the high land facing the prevailing wind, sometimes on the low land most sheltered. Experience of mapping monthly totals of rainfall revealed a general but by no means a regular distribution of rain greatest on the high lands and least on the low ; and the mapping of individual annual totals showed a general identity of distribution, though the value of the isohyetal lines represented varied from year to year. It took the work of some years to show clearly that rain falling in thunderstorms and in cyclonic disturbances of comparatively small size was distributed on the whole in accordance not with geographical but with meteorological conditions, and was probably determined at heights considerably greater than that reached by any part of the land. Reasoning showed that the rain-fields of such heavy falls might occur over any part of the land and probably over any part of the adjacent sea, according as the track of the atmospheric disturbance producing it happened to run. It was fair to assume that in a year heavy falls would occur in many parts of the country and in a great number of years in all parts of the country, so that in a map of absolutely normal conditions rain of this type would show a uniform depth over the whole surface ; in other words, it would only affect the numerical value of the isohyetals, leaving the form of the isohyetals to be determined by rain of a non-cyclonic or non-thunder-storm origin.

In order to see what this distribution actually was, a map was prepared from 380 stations with rainfall averages of 30 years. [3] These were not so uniformly distributed as one would like, but when plotted on a blank map with no orographical features shown, the data yielded isohyetals showing a startling similarity to the contour lines of elevation on the same scale. There was no doubt that, on the average, the distribution of rainfall was determined by configuration. It is a meteorological rather than a geographical matter to explain the apparent anomaly. Still I may say that it arises from the fact that the ascent of moisture-laden air produces rain ; when this occurs from a meteorological cause independent of the land surface, the resulting rain falls on the ground, be it high or low, which happens to be under the rising mass of air. But when the air is flowing in from the sea or across low land in a practically horizontal sheet, it must be forced upwards on reaching the hills by the surface of sloping land acting like a wedge. As the air rises the rain falls, the amount depending on various factors, amongst which the slope of the land is of great importance.

It is clear that the direction from which the wind comes is very important as a factor of rain distribution, for land rarely presents the same slope to all sides. In the few cases of heavy rains occurring with westerly wind and straight isobars, which mean a current of air from the prevailing direction without cyclonic uplift, the map of a day's rain is strikingly similar to that of a normal month or a year, thus indicating the predominance of horizontal winds on the average of a year or of many years. To precipitation of this type the name of orographical rain has been applied.

So far a general study of rainfall in any large area would lead to the same result ; but when we attempt to give a quantitative value to the influence of wind-direction, land slope, and altitude, detailed study of a particular region is essential. The conditions for such study are very onerous. The region must be studied not only from maps, but on the spot. Rain gauges must be established at fairly close intervals and read under skilled supervision to avoid errors. Methods must be found for computing sound averages, so that the means of irregular periods may be compared safely, and every step of the work must be rigidly checked so as to stand the sharpest criticism. It is not too much to say that unless the result of the work was of great and urgent practical importance, these conditions could never be met. The way they have been met has not been set out fully in public before.

In this country the law provides that no scheme for water supply can be carried out by any company or public authority without the sanction of a special Act of Parliament, which is promoted by what is called a Private Bill. There are various forms of procedure, but normally each Private Bill is examined by a Committee of each House of Parliament separately, a member of the Parliamentary Bar states the case of the promoters before the Committee, and anyone who has reasonable cause to anticipate that he may be injured by the provisions of the Bill, then states his objections through counsel, after which the Committee decides whether to recommend Parliament to pass the Bill as it stands or after amendment, or to reject it. Expert witnesses who have previously given reports on which the Bill has been framed or by which it is attacked are called before the Committee, examined by an eminent King's Counsel and cross-examined by another, or by half a dozen others, in the effort to shake the evidence. This is a very different test of the validity of scientific deductions from the discussion that takes place after a paper has been read at a scientific society, and I have never known any keener incentive to thorough preparation and clear exposition. As in all the great Water Bills of the present century, the amount of water available on the ground selected has been determined by means of an average rainfall map specially prepared by the Director or Superintendent of the British Rainfall Organization, the promoters have naturally supplied every facility for obtaining an accurate map. And as in every case this map has been compiled so as to fit the maps of adjoining areas, a large part of the country has been dealt with. A large part of the country was also mapped with exactly the same precautions for the Water Supply Memoirs of many counties which were published by the Geological Survey, and when I was obliged to stop work, practically half of the area of the British Isles had been covered by an average rainfall map on the scale of 2 miles to 1 inch.

I have laid stress on the economic and legal environment in which the work was done, as I think it is unique for any piece of scientific research. In many cases an increase of one inch in the estimate of average annual rainfall would mean an increase in the cost of the necessary engineering works of £10,000 at pre-war rates or anything up to £30,000 at present prices. On the other hand, if the estimate were made a few inches too low, it might mean the abandonment of the only reasonably cheap source of supply for a great city. Between two such burdens of responsibility one can only look straight forward, aiming at the highest possible accuracy ; for in such work one cannot seek refuge on " the safe side," as each side of the truth is beset with its own dangers. The tradition established under such sanctions will, I trust, hold under the Air Ministry until the average rainfall map has been completed by the Rainfall Organization for the whole area of the country.

When trying to construct a rainfall map of high accuracy, one longs for the ideal physical map as a basis, but one must be content with the best available. At present there are not enough rainfall data in most parts of the country to justify the use of so large a scale as 1 inch to 1 mile, though we were able to use that scale for the Lake District of England. In most cases 2 miles to 1 inch is a suitable scale, and for most parts of the country nothing could be better than the Ordnance Survey layer map of that scale. This map is disfigured by the crude green patches representing woodlands, but otherwise its colouring is strictly consistent, the same tints being used for the same ranges of level in all parts of the country. Unfortunately in practical life absolute consistency often lands its practitioner in difficulties, and here the slight contrast between successive tints gives a somewhat flat aspect to many districts where the change in level is gradual. Bartholomew's half-inch layer map, the forerunner of the official issue, is free from this defect, as the range of colours is varied so as to ensure effective contrast, and in practice I have used whichever map happened to be the more convenient for the district under study.

The computation of correct averages for each rainfall station is complicated and difficult ; but as it is not a geographical point I pass it over. When the figures have been placed on the map, each on the site of the rain gauge which furnished it, the geographical part of the task begins. The interval between the successive isohyetal lines shown depends largely on the scale of the map. For the half-inch scale I have found 5 inch intervals always practicable except in regions of very high rainfall and rapid change ; in regions of lower rainfall it is often possible to have smaller intervals, and I havee then used 2½ inch steps.

Having before one a half-inch layer map, with all the available average rainfall figures which have emerged from the statistical tests (not referred to here), the problem is reduced to. drawing the isohyetal lines for the adopted intervals. If the figures were arranged uniformly over the map, say at intervals of an inch each way, it would probably suffice to fix the position of the isohyetal between each two figures by a dot which divides the distance proportionally as judged by the eye, and then to connect these dots by lines. But even in this impossibly simple case the question of curving the lines must be considered. To join the points by straight lines would be absurd, for straight lines so rarely represent any natural feature on the surface, that without strong corroboration they cannot be accepted as correct. Since height above sea-level has been shown to have a close association with increase of rainfall, the assumption that the isohyetjals should be drawn generally parallel with the contour lines is natural ; and the study of an actual map—which happily has usually some places where figures cluster closely, as well as many where they are deplorably wide-spread—abundantly justifies this assumption. The clustered figures give the clue to the general run of the isohyetals, even although they define only a short stretch at a time ; and by applying the relation between contours and isohyetals demonstrated in the clustered portions to the thin places, it is possible to stretch a probable line along a great part of the map. By long practice one acquires an almost, instinctive insight into the sympathy between isohyetals and land forms. One learns to refine upon the first crude approximation of parallelism and make allowance for the gradual climbing of the isohyetals from contour line to contour line along slopes which run in the direction of the prevailing wind. Faith in the relation which has gradually emerged is justified by the fact that sometimes a series of records is discovered which were unknown when the map was drawn, and the new figures are found to fall as neatly between the isohyetals as if they had been the original data from which the lines had been drawn. [4] One may be impelled to sketch in lines on blocks of country where no observational data exists, and even to conjecture what the maximum rainfall on an un-gauged mountain top may be ; but this is a dangerous game. A tailor may venture to cut out a coat for an unmeasured customer, and might even put together a garment which mighty be near enough to try on ; but at the very best he would require a lot of tearing asunder, letting out, and taking in, before the coat would fit. Even a measured coat takes some fitting, and the best measures for a rainfall map are very far from being comparable to a tailor's measurements, so that a vast amount of re-adjustments must be expected before isohyetal lines sketched without numerical data can fit the land.

One must always be on the alert not to allow theoretical considerations, which are so helpful in the absence of tested data, to tempt one to disregard actual figures even when they seem to be contradictory. It is true that bad figures can be detected by their disagreement with the majority of the figures around them; but they must not be disregarded on that account until a statistical investigation or an inspection of the rain gauge responsible for them shows that they are untrustworthy.

In mapping the rainfall on the slopes of a uniformly rising ground, such as the western face of the Welsh mountains or the Lake District or Bowland Forest, one becomes so accustomed to the uniform increase of rainfall with height, that when one finds higher figures in the valleys to the east it is disconcerting. In many cases, however, there is no getting over the fact that places a few hundred feet above sea-level have higher rainfall than places a few thousand feet above sea-level to windward of them, and the isohyetals must be drawn to fit the facts. This is the case at the Stye below Stye-head Pass in the Lake District, in the valley east of the Black Mountain in Monmouthshire, and at a great many other places, even where the orography is as gentle as in the case of the North and South Downs.

The explanation leaves the general principle of the influence of configuration on average rainfall not shaken, but strengthened. In part it is due to the bodily transport of sheets of rain over the ridge by high wind before the drops have time to fall, and then the phenomenon is accompanied by a lower recorded rainfall on the hill tops than their elevation and exposure would suggest. But in part it is accounted for by the continual progress of the air blowing along the windward hill-slopes upward as well as onward, so that increased precipitation induced by the high altitude drops into the valley on the other side, in the same amount that would have fallen on the hill if it had continued to run up to the height reached by the wind shooting beyond its summit. There are indeed some instances where the amounts of rainfall observed are at variance with the relationships which prevail in adjoining localities, and these are problems of promise for future investigation.

Meanwhile I may quote the general principles arrived at some years ago, [5] as I think they will stand the test of time :

1. There are no abrupt transitions in average rainfall.

2. The rainfall on the windward slope of a hill increases from the lower to the higher

levels, although not necessarily at a uniform rate.

3. The rainfall on the leeward slope of a hill is frequently greater at some point on the slope than it is at the summit.

4. When two portions of land of similar configuration have the same exposure to the prevailing wind, the distribution of rainfall is similar.

Mr. Salter has gone somewhat further in discussing the work which we have carried out together, with a view to assigning numerical values to the relation between configuration and rainfall. [6] The result will be that as research continues and experience instructs, the compiler of such maps will be enabled to draw his lines firmly on the basis of sparser data than could be trusted formerly. I hope, also, that as time goes on, the number of observations will increase in the bare patches, so that eventually a really complete representation of the distribution of rainfall may be cast like a garment (and like a perfectly fitting garment) upon the naked land.

No attempt has yet been made to plot the rainfall of individual months or years on large scale orographical maps ; but this promises results of the deepest interest if carried out for regions where rainfall stations are numerous and in conjunction with data regarding winds,

A Water Geography.

The mapping of average rainfall is not a matter of academic interest merely, but one of high public importance. It; is an essential step towards a complete water geography of the country, which has become an urgent necessity. The vital importance of the water resources of a country has hitherto nearly escaped general attention. The enormous quantities of water required for the supply of populous areas have in the past been obtained easily from deep wells or from conveniently situated moorlands. Canals, which absorb an immense volume of water in working the locks, have been allowed to become an insignificant element in our transport system, and our vaunted supplies of cheap coal have kept the eyes of manufacturers averted too long from the possibilities of water-power. But the old happy-go-lucky days are over. The most convenient moorlands have all been utilized or pegged out by far-seeing communities, and many a municipal brain is sorely worried to find new gathering grounds. The deep wells have to be deepened every year to keep pace with the sinking level of the reservoir of underground water. There is a talk of reviving the canals ; there is a new and urgent call for condensing water for the great electric supply systems now being established, and with the growing price and scarcity of coal, the need for water-power and the possibility of its economic installation are being forced on the mind of the public.

We know enough of the rainfall to be certain that enough water is always pouring down upon this country to satisfy all demands that need to be made on it ; but its natural distribution has to be studied, and its use requires to be controlled so that the best return can be obtained from each river-basin. We require to ascertain exactly how much water can be counted on for continuous supply throughout the year—a physical question—and what communities are to be served from each gathering ground—an economic and political question of extraordinary complexity, for the use of water by one community must not be allowed to prejudice the claims of other communities near or remote. It is on account of the complexity of the problem that the terms of reference of the Water Power Resources Committee of the Board of Trade have had to be widened to include an enquiry into all uses of water.

The natural unit for a water geography is, of course, the river basin, or, as engineers often call it erroneously, the watershed. An ideal physical map of any British or Irish river basin could be prepared from the Ordnance Survey sheets, by a few additions. First comes the insertion of the watershed bounding the drainage area, which can be sketched in easily enough on a small scale map ; but seldom on the one-inch scale without occasional reference to the country itself, and there is probably no more difficult task in surveying than fixing the water--shed on a six-inch map of a flat-topped moorland. Another desirable addition is the fixing of levels at various points in the bed of streams, and this is of vital importance if the map is to be taken as a guide to water-power, for the power of a given weight of water depends entirely on the distance through which it falls. A correct profile of a river bed cannot be drawn from the contours as shown on the ordinary map, and it is very important to be able to set out the vertical fall of a river bed in this way. Now bearing in mind how the configuration of the land ensures that the heaviest rainfall descends on the head waters or torrential portion of a river, one sees that this is the region where most power can be generated, taking advantage of the high falls ; and here the natural untamed power of the falling water has done most work in carving out its deep and steep-sided ravines. Lower down the valley the course of the river has a gentler gradient, but still sufficient to ensure a rapid current, and as the waters converge upon it from many torrents, the increased volume of water secures a great source of power due to large volume with a low fall. The valley course of a river is habitable and cultivable in opposition to the desolate and barren torrential track, and here in the earlier days power was first used. Throughout this section the river carries along stones and sand, and too often it is compelled also to carry a load of sewage from the towns it passes. Farther down, in the Plain course, the typical river winds with reduced gradient and falling velocity, slowly towards the sea. It can no longer transport heavy matters, and drops its load of silt, ever reducing the gradient of its bed and the speed of its flow. The practical problem here is how to get the water to pass along fast enough to prevent 'the flooding of valuable agricultural land along its course.

As every river differs from its neighbour in the relative lengths of the three typical divisions of its course, each river-basin must be studied geographically as a separate unit. The rainfall map tells only how much water falls on the different parts of the surface in an average year. Special investigations are required to ascertain how much water flows off the surface and occupies the river-bed at each point, how much evaporates and returns to the air, and how much percolates through the soil to replenish the deep-seated reservoirs of under-ground water. A hydrometric survey is necessary for this purpose, with special gaugings of river-flow at important points. But in order to understand the ratio between run-off and percolation, it is necessary to take account of the geological structure and the nature of the rocks and soil, for there are all grades of permeability, from the smooth walls of the highland schists, which shed practically the whole of the rain into the rivers, to the waterless surface of the chalk downs, where every drop that falls is absorbed into the porous rock. More, it is necessary to consider the covering of vegetation and the result, on evaporation, run off, and percolation ; of bare stone surfaces which throw all the rain off at once ; or of spongy peat mosses, which may absorb a week’s rain after a long drought, and ooze out a uniform supply to the stream for weeks thereafter. Equally marked is the contrast in the effect of grass, and still more of trees in summer, when the transpiration of water into the air is enormously accelerated, and the thoroughly drained agricultural land, which rapidly withdraws water from the surface and passes it on free from evaporation by shallow springs to the streams, and by deeper channels to the underground stores.

From the scientific view-point of the geographer, the main interest of a water-geography is that it describes a circulation in which water is merely a medium for transforming solar energy into work or the potentiality of work upon the Earth’s crust, which guides the working of the system. But to the engineer or other practical man the interest lies in controlling the energy, so that the amount available for generating power or supplying cities may be calculated, and due provision made for maintaining navigation in the lower stretches, maintaining free passage for fish when these are of economic importance, and preventing floods and placing no impediment in the way of land-drainage or of the carrying away of any deleterious substances that may be allowed to enter the lower reaches. From this point of view a complete water geography would amply repay the cost of compilation, and the Second Interim Report of the Water Power Committee of the Board of Trade recommends such work as one of the functions of a Central Commission for the Control of Rivers, the appointment of which is urged.

Memoirs on water geography could not be compiled for any river-basins by taking account merely of the forms of the land, its geological nature, the vegetation, and the amount of the water.

No complete scheme could possibly leave out of account the industrial processes which have been set up on the streams or in the valleys, the sources of power for factories involving the relation of the stream which supplies condensing water to the nearest supplies of coal and iron, the railway, and road communications between them, the grouping of population and its migrations, the political divisions into rural and urban districts, boroughs, counties, and numerous joint authorities with their intersecting and overlapping jurisdictions.

In fact, the compilation of a rainfall map, which was undertaken as a refuge from the bewildering maze of a complete regional geography, leads back through the portals of a geography of inland waters to something very like the old 1896 scheme.

The practical question of providing the machinery for producing regional geographical memoirs, or the more specialized memoirs on river basins, presents many difficulties. If it is to be attempted by any Government department, the scope and treatment will necessarily be influenced by the immediate purpose in view. Hitherto men of science have often been dissatisfied with the researches carried out by government departments, not because there are not able men employed on them, but rather because the wider aspects of the work are under the control of Ministers, who are not, as a rule, instructed in scientific methods or in sympathy with the scientific spirit. The regional memoirs would require co-operation between many departments at least the Ministry of Agriculture and Fisheries for the Ordnance Survey and other things, the Admiralty for the Hydrographic Survey, the Department of Scientific and Industrial Research for the Geological Survey, the Air Ministry for the British Rainfall Organization, the Ministry of Health for Water Supply, the Board of Trade for Water Power ; and in each case the particular subject named forms a mere fraction of the work of the Department in question, while the head of each Department may change every few months. Had the opportunity been taken when a Scientific Research Department was established, to bring under it all the surveys to which I have referred, it would have been possible to have a co-ordination between the various branches of Earth science which would have greatly strengthened each of them ; but that opportunity was lost. I am full of admiration for the ability and devotion of the high officials placed in control of each of the scientific activities I have named ; but they are all hampered by the system of which they form part, and all are responsible to chiefs whose main interest lies in a different direction. Hence it is, in my opinion, unlikely that we shall find either the freedom or the incentive necessary for successful original scientific work in the existing departments.

It seems to me that its natural home would be in some University or kindred institution, where a Professorship of Geographical Research might be founded as soon as a sufficient number of trained geographers have been produced to compete worthily for the post. It should be equipped with ample and unconditioned funds, provided, perhaps, by the not impossible millionaire who may desire to possess the remainder of his wealth with an easier mind. Data should be sought from all sources ; but worked up only by trained geographical students, each adequately paid, subject to summary dismissal if inefficient, and open to promotion if able and eager to take advantage of his opportunities. There should be no haste to provide showy results, no cessation in the search for fresh facts and better methods. Research and teaching go hand in hand, and practical application is a helpful companion to both. Hence I should like to see the institution I have in mind closely associated with instruction in engineering, forestry, and agriculture, so that those whose business it is to make use of natural resources, should have the fullest and most stimulating education in the theoretical as well as the practical foundations of their calling.

But I fear that I am indulging in seductive dreams again.

[1] Geographical Journal, April, 1896.
[2] Geographical Journal, March and April, 1900.
[3] Min. Proc. Inst. C.E., Vol. 155 (1903-4), Pt. I.
[4] See *British Rainfall*, 1915, p. 29.
[5] *British Rainfall*, 1915, p. 28.
[6] Proc. Inst. Water Engineer, 23 (1918), 45-9, and *British Rainfall*, 1918, pp. 40-56.

The new branches of the Association created this year are situated at Bishop Auckland, Bristol, Crewe, Essex, Exeter, Hereford, Lincoln, Leicester, Nottingham, Plymouth, E. Suffolk, Swansea, Thanet, Tottenham, and York, making a present total of 40 branches in England and Wales. In addition to the above, we record with pleasure the continuation of the activities of the affiliated Association in Ireland under conditions of difficulty which command our utmost sympathy.

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