a lake's outlet is regulated by the discharge, and is not affected by slow changes in the attitude of the basin; but at other points of the shore the water advances or retreats as the basin is tipped. Consider, for example, Lake Superior. On the map (Fig. 1) a line has been drawn through the outlet at the head of St. Marys River in a direction at right angles to the direction of tilting. All points on this line, called the *isobase* of the outlet, are raised or lowered equally by the tilting, and are unchanged with reference to one another. All points south-west of it are lowered, the amount varying with their distances from the line, and all points to the north-east are raised. The water, always holding its surface level, and always regulated in volume by the discharge at the outlet, retreats from the rising north-east coasts, and encroaches on the sinking south-west coasts. Assuming the rate of tilting to be 0·42 foot per 100 miles per century, the mean lake level is rising at Duluth 6 inches per century and falling at Heron Bay 5 inches. Where the isobase intersects the north-western shore, which happens to be at the international boundary, there is no change.

Lake Ontario lies altogether south-west of the isobase of its outlet, and the water is encroaching on all its shores. The estimated vertical rise at Hamilton is 6 inches per century. The whole coast of Lake Erie also is being submerged, the estimated rate at Toledo and Sandusky being 8 or 9 inches per century.

The isobase of the double Lake Huron-Michigan passes south-west of Lake Huron and crosses Lake Michigan. All coasts of Lake Huron are therefore rising as compared to the outlet, and the consequent apparent lowering of the mean water surface is estimated at 6 inches per century for Mackinac, and at 10 inches for the mouth of the French river on Georgian Bay. In Lake Michigan the line of no change passes near Manistee, Michigan. At Escanaba the estimated fall of the water is 4 inches per century; at Milwaukee the estimated rise is 5 or 6 inches, and at Chicago between 9 and 10 inches.

These slow changes of mean water level are concealed from ordinary observation by the more rapid and impressive changes due to variations of volume, but they are worthy of consideration in the planning of engineering works of a permanent character, and there is at least one place where their influence is of moment to a large community. The city of Chicago is built on a smooth plain little above the high-water level of Lake Michigan. Every decade the mean level of the water is an inch higher, and the margin of safety is so narrow that inches are valuable. Already the older part of the city has lifted itself several feet to secure better drainage, and the time will surely come when other measures of protection are imperatively demanded.

Looking to the more distant future, we may estimate the date at which the geographical revolution, prophesied by Spencer, will occur. Near Chicago, as already mentioned, is an old channel made by the outlet of a glacial lake. The bed of the channel at the summit of the pass is about 8 feet above the mean level of Lake Michigan and 5 feet above the highest level. In 500 or 600 years (assuming the estimated rate of tilting) high stages of the lake will reach the pass, and the artificial discharge by canal will be supplemented by an intermittent natural discharge. In 1000 years the discharge will occur at ordinary lake stages, and after 1500 years it will be continuous. In about 2000 years the discharge from Lake Michigan-Huron-Erie, which will then have substantially the same level, will be equally divided between the western outlet at Chicago and the eastern at Buffalo. In 2500 years the Niagara river will have become an intermittent stream, and in 3000 years all its water will have been diverted to the Chicago outlet, the Illinois river, the Mississippi river, and the Gulf of Mexico.

FORESTS AND RAINFALL.[1]

CAN it be possible that the cutting away of forests affects the amount of precipitation in any locality? To many, no doubt, this question will seem easy of answer; but we find the results of study by no means reassuring, and recent investigations have led to almost diametrically opposite conclusions, depending, somewhat at least, upon the feeling of the writer. When we reflect that our rain storms are of very wide extent, oftentimes over 1000 miles in diameter, and may take their origin and bring their moisture from distances of 1000 miles or more, the thought that man, by his puny efforts, may change their action, or modify it in any manner, seems ridiculous in the extreme.

It has been well established that forests have a most important bearing upon the conservation of rainfall; that the forest floor permits a seepage of water to the source of springs, and thus maintains their steady flow; that they hold back the precipitation that falls, especially in the form of snow, thus preventing or ameliorating the effects of dangerous freshets. There is not the slightest doubt of their great importance to the welfare of man, but all these facts do not affect the question of their influence upon precipitation. The following paper is prepared from the standpoint of a meteorologist, and is an attempt to present facts.

The Historical Argument.

Formerly the historical argument was a favourite one. I quote one of these: "It is a familiar fact that there are many regions in Asia and southern Europe, once exceedingly fertile and densely populated, that are now utterly sterile and desolate. The country bordering on the Euphrates and portions of Turkey, Greece, Egypt, Italy and Spain are now incapable of cultivation from lack of rain due to deforestation." The most fertile of all provinces in Bucharia was that of Sogd. Malte Brun said, in 1826, "For eight days we may travel and not be out of one delicious garden." In 1876 another writer says of this same region: "Within thirty years this was one of the most fertile spots of central Asia, a country which, when well wooded and watered, was a terrestrial paradise. But within the last twenty-five years a mania of clearing has seized upon the people, and all the great forests have been cut away, and the little that remained was ravaged by fire during a civil war. The consequences followed quickly, and this country has been transformed into a kind of arid desert. The water-courses are dried up and the irrigating canals are empty." It has also been said that in the older settled portions of New England and the Middle States there are arid hills and worn-out fields, due to the falling off of precipitation from the cutting away of the forest growth. Such quotations and statements might be made to fill a large volume. Without more precise data as to rainfall it would be hazardous to conclude that we have here a case of cause and effect. It is certain that the fertility of these regions in ancient times was due to stupendous irrigating devices and canals, and when these were neglected, through wars and other untoward circumstances, the fertility necessarily ceased. It is certain that there are ruins of enormous irrigating ditches and canals in Babylonia, where history indicates that there was once a teeming population and great fertility, but where now only a sandy desert greets the eye.

Constancy of Rainfall.

It has been said that where our densest forests are found there we have the greatest precipitation. There is no way whereby we can see that such forests would have started unless favoured by rainfall, so that the presence of the forest rather indicated the earlier occurrence of practically the same rainfall as at present. Meteorologists are agreed that there has been practically no change in the climate of the world since the earliest mention of such climates. Plants found in mummy cases in Egypt that were plucked thousands of years ago show the same size as those now found in that land. The "early and the latter rains" are experienced in Palestine to-day just as they were four thousand years ago. Jordan "overflows all its banks" to-day, in February, precisely as it did in Joshua's day. When we come down to recent times and to the records of rainfall measured in New England for more than one hundred years, or, at least, before and since the forests were cut, we find a constancy in the rainfall which shows its entire independence of man's efforts. Here it should be noted that totally barren lands of any extent, in New England for example, are to be found only in imagination. Even where the forest has been cut away mercilessly there springs up a growth of sprouts which covers the ground, and answers almost the same purpose in causing rainfall (if there is any effect of that kind) as the forest. Even where land is entirely cleared of a forest we have at times the green pasture, and at others still heavier crops which leave the ground anything but a sandy waste.

Rainfall Measurements in Forests and Open Fields.

But the strongest argument adduced in the past to show the influence of forest on rainfall has existed in a comparison between rain-gauge measures in the forest and the open field

[1] A paper by Prof. H. A. Hazen, presented at the annual meeting of the American Forestry Association at Nashville, Tenn., September 22. (Abridged from the *Monthly Weather Review*.)

Such records have been made for more than thirty years in France and Germany, and surely we must have here, if anywhere, a sufficient proof of a forest's influence.

Admitting that we have perfect instruments and careful observers, there still remains a most serious doubt as to the immediate environment of each gauge and as to the possibility of a direct comparison. It is probable that no two gauges 2000 feet apart can be placed so as to catch the same amount of rain, though to all appearances the exposure is faultless in each case.

Extreme caution is therefore needed in arriving at conclusions from comparisons between gauges in forests and in the open. One of the best of all researches in this line has been conducted at Nancy, in France. Within a distance of five or six miles there have been four stations established. At Nancy in the open, and at Belle-Fontaine in the forest; and, 500 feet higher vertically, Amance (open) and Cinq-Tranchées (forest). At Nancy and Belle-Fontaine the observations extend over twenty-five years. A comparison of the records in groups of eight, eight, and nine years was made, with the result that while the first eight years showed a very slight excess in the forest rainfall over that in the open field, in the last nine years (including 1894, last published) the open station showed a little more rain than the forest station. These observations were made with particular care, for the purpose of exactly determining the influence, and may be relied on if the environments of the gauges were comparable. At Amance (open) and Cinq-Tranchées (forest) the observations have not been quite so regular, though there are twenty-five full years of records at these two stations, but not the same years as at the other stations. The comparison in this case makes the rainfall more than 20 per cent. greater in the forest than in the open. It should be borne in mind, however, that these two stations are on an eminence, and are not strictly comparable, and this result cannot vitiate that at the two other stations, which shows no effect.

In Germany we have a rather remarkable record of a slightly different character. Lintzel is a station on the Luneburg Heath, which began to be planted with trees in 1887, at the rate of 1000 to 1500 acres a year, and in a few years over 8000 acres were covered. In the midst of this forest is the meteorologic station in an open field of some seventy-five acres. Before planting the forest, 97 per cent. of the surface was field, meadow, or heath, and afterwards 80 per cent. was forest and 20 per cent. was roads, open field, and heath. Around this station, pretty evenly distributed, and within fifty miles, there are thirteen rainfall stations which have been carefully established, and presumably are comparable with the Lintzel station in the midst of the growing forest. There are no means of knowing whether any of these stations have been changed or not, but for our purpose we may consider the material homogeneous, and treat it accordingly. Records from 1882 to 1896 (fifteen years) are available. Charts were prepared for each year showing the ratio between the Lintzel record and that at each station of the thirteen. The results do not show that the afforestation has had any appreciable effect upon the precipitation; in 1884 the ratio was 101, while in 1893, nine years later, it was 96. It is probable, however, that no definite and unassailable result can ever be obtained either by the method adopted in France or this later one in Germany. The rainfall is so variable within a distance of even a mile or two; and it is so difficult, if not impossible, to obtain similar environments at all the stations, that no decisive result can be obtained. It will be readily seen that the multiplication of stations will do no good, and, above all, that the observation of rainfall under trees in a forest is absolutely useless for any such discussion or study as this.

Need of Further Evidence.

It seems probable that if two or three lines of stations could be established a mile or two apart on four sides of an enormous forest, each line to have a dozen stations or so, about 3000 feet apart, four of the stations to be outside of the forest, and the others each in a large cleared space of at least two acres extent in the forest, something decisive might be obtained. It should be noted, however, that from the evidence already accumulated there would be very little to be gained by a further study of the question. It is certain that the effect, if there be one, is almost inappreciable. The favouring conditions over the forest are balanced by those not favouring, and the integrated effect is practically the same in the two cases.

Prof. H. F. Blanford determined from a most careful series of records, from which all known errors had been eliminated, that the forest had a tendency to give 2 per cent. more rain than contiguous open fields. That is, if an open place had 50 inches of rain in a year, a near-by forest would have only 51 inches, which is practically inappreciable.

It would be an interesting study to select all those cases in experiments in forest and near-by fields in which the wind was blowing either from the forest to the field, or *vice versâ*. It is evident that if there is any effect on rainfall by the forest, it would be vitiated, if not exactly reversed by such winds.

There is a class of visual observations which seem to show an effect upon rainfall by the forest. Probably many have seen heavy clouds passing over a plain, but which only precipitated as they passed over a forest. Also in a hilly region it is a frequent phenomenon that fog and low-lying cloud hover near a forest, and not over an open plain. One also notes very often, in passing into a forest on a damp day, that the trees drip moisture, possibly condensed from moisture evaporated from the damp earth underneath. Observations of this nature, however, cannot ordinarily be checked by instrumental means, but show in a general way that the forest tends to conserve vapour and moisture which in the case of the open field would be diffused into the atmosphere.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. G. H. RENDALL, the Principal of University College, Liverpool, has been appointed Head-Master of Charterhouse School.

SIR JOHN GORST, in the course of an address at Bristol on Thursday last, is reported by the *Times* to have said that the promotion of technical education was confronted by two obstacles—the backward condition of elementary education and the want of organisation in the provision of secondary education. A good sound system of elementary education must be the groundwork for higher education, and he urged reform of the system which at present relieved children from compulsory attendance when inadequately equipped. The improvement of the organisation of secondary schools was really a matter for the people themselves. There was nothing to prevent technical instruction committees from becoming thoroughly representative and effective organisations.

THE most satisfactory point to us in the Report just issued by the Oxford University Extension Delegacy refers to the Extension College at Reading. The college is doing excellent work, more particularly in agriculture, and has amply justified its existence. New buildings are, however, imperatively needed, and in response to an appeal for 12,000*l*., 9,000*l*. has already been promised, and the new wing has been begun. The building scheme, planned four years ago, will be completed by next summer, and H.R.H. the Prince of Wales has promised to perform the opening ceremony. The educational work of the college has been attended with great success during the past year. With regard to the courses of lectures delivered under the auspices of the Delegacy during the year 1896-97, we notice that out of a total of 146 courses, only nineteen were on scientific subjects.

IN the course of a presidential address recently delivered before the Kansas Academy of Sciences, Prof. S. W. Williston severely criticised the system of education which makes language studies compulsory, and all, or nearly all, the sciences optional. Many educationists will find themselves in agreement with the following opinions expressed by Prof. Williston:—"I claim broadly and emphatically that the natural sciences, any or all of them, are as valuable and as necessary as pure cultural studies as are the languages; that intelligent and successful study of them will do as much, if not more, in making the student a broad man, a successful man, as will the study of Latin or Greek. And they will do more in making him an honest man. Nowhere in all the broad field of knowledge will he learn better to think exactly than in the natural sciences. Nowhere will he be more impressed with the importance of truth for truth's sake. . . . Were I, then, to say what the universities and colleges ought to do, it would be this: make all the ancient language requirements for admission optional, and demand as much preparation in the physical and biological sciences as in the foreign languages. The preparation in English should be made far more rigorous